JOURNAL OF THE A·I·E·E·

DECEMBER 1930



PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST. NEW YORK CITY

FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
New York, N. Y.	Jan. 26-30, 1931	Winter Convention	(Closed)
Pittsburgh, Pa.	March 11-13, 1931	District Meeting	Dec. 11, 1930
Rochester, N. Y.	May 6-9, 1931	District Meeting	Feb. 6, 1931
Asheville, N. C.	June 22-26, 1931	Summer Convention	March 23, 1931
Lake Tahoe, Cal.	Aug. 25-28, 1931	Pacific Coast Convention	May 25, 1931
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931

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MEETINGS OF OTHER SOCIETIES

The American Society of Mechanical Engineers, Annual Meeting Engineering Societies Building, 33 West 39th Street, New York, N. Y. (Calvin W. Rice, Secretary) December 1-5, 1930.

The American Physical Society, 167th Regular Meeting (in joint session with the Acoustical Society of America), University of California, (Leonard B. Loeb, Local Secretary, University of California, Berkeley, Calif.) December 12-13, 1930; Annual Meeting Cleveland, Ohio, December 30-31, 1930; 169th Meeting, New York, N. Y. (W. L. Severinghaus, Columbia University) February 27-28, 1931.

Pacific Coast Electrical Association, Engineering Section, Los Angeles, California, (S. H. Taylor, 447 Sutter Street, San Francisco) December 10-12, 1930.

American Engineering Council, Annual Meeting, Washington, D. C., (L. W. Wallace, 26 Jackson Place, Washington), January 15-17, 1931.

Midwest Power Engineering Conference, Chicago, Illinois (G. E. Pfisterer, 308 W. Washington Blvd., Chicago), February 10-13, 1931.

National Electric Light Association, Engineering Section, Minneapolis, Minn. (J. W. Lapham, 803 Plymouth Building, Minneapolis) February 23-24, 1931.

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Attendance at Conventions.—Taking part in the Institute conventions is one of the most useful and helpful activities which membership in the Institute affords. The advantages offered lie in two distinct channels; technical information and personal contacts. The papers presented are largely upon current problems and new developments, and the educational advantages of hearing and taking part in the discussion of these subjects in an open forum cannot but broaden the vision and augment the general knowledge of those who participate. Equally advantageous is the opportunity which conventions afford to extend professional acquaintances and to gain the inspiration which grows out of intimate contact with the leaders in electrical engineering. These conventions draw an attendance of from 1000 to 2000 people and constitute milestones in the development of the electrical art.

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The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Societie Francaise des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Norsk Elektroteknisk Forening (Norway), Svenska Teknologforeningen (Sweden), Elektrotechnicky Svaz Ceskoslovensky (Czechslovakia), The Institution of Engineers, Australia (Australia), Denki Gakkwai (Japan), and South African Institute of Electrical Engineers (South Africa).

Abridgment of

Large Hydroelectric Generators

The Trend in Design and Capacity

BY M. C. OLSON*

Associate, A. I. E. E.

Synopsis.—*The paper describes recent developments in design of large hydroelectric generators. New features of mechanical construction made possible by fabricated designs are particularly emphasized and illustrations of some recent machines given. The 77,500-kv-a. generators for the Dneprostroy Project in Russia, (which will be the world's largest hydroelectric generators) are described. In conclusion, some of the future possibilities, such as outdoor machines and multi-speed designs, are discussed.*

WITHIN the last few years many changes have been introduced in the mechanical and electrical design of large hydroelectric generators. The purpose of this paper is to present a few of the salient features of some recent installations, and to indicate the trend of progress in design of this class of machines as indicated by the experience of one manufacturer.

Fig. 1 shows the trend in maximum capacity of large vertical hydroelectric generators built by one company during a period of 30 years. The largest

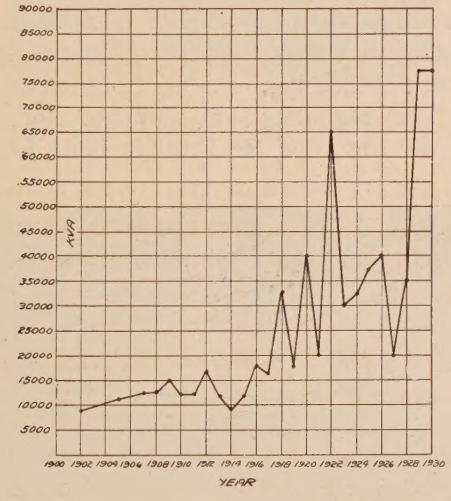


FIG. 1—TREND IN CAPACITY OF LARGE VERTICAL HYDROELECTRIC UNITS

units shown on this curve are the 77,500-kv-a. generators which are now being built for the Dneprostroy Hydroelectric Development, Russia. These machines will be the world's largest hydroelectric units both as to rating and physical size.

Fig. 2 shows the trend in maximum capacity of large horizontal hydroelectric generators built by the company during this same period above mentioned. The largest unit shown on the curve is the 55,000-kv-a. 360-rev. per min. generator now being built for the Sao Paulo Tramway Light and Power Co., Brazil. This generator will be driven by double, overhung impulse waterwheels.

FABRICATED CONSTRUCTION

During the last few years, due to the use of rolled steel plates and fabricated structures in place of castings, radical changes have been made in the design, construction and appearance of hydroelectric generators. As a result of the introduction of welded steel plate construction, generators have been made more reliable mechanically, lighter in weight, and much more adaptable for special ventilating or constructional requirements; shorter deliveries have also been made possible. With a range of speeds from 60 to 720 rev. per min., hydroelectric generators must have widely varying designs which can be made more easily with fabrication than with the older cast construction.

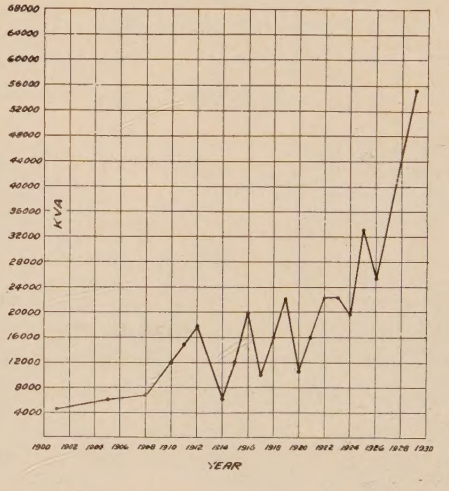


FIG. 2—TREND IN CAPACITY OF LARGE HORIZONTAL HYDROELECTRIC UNITS

One of the first large generators of completely fabricated construction was the 33,000-kv-a., 125-rev. per min., 6600-volt generator for the Brazilian Hydro-Electric Company. (Fig. 5.) This machine has practically no castings. The upper bearing bracket is a fabricated

*A-c. Engg. Dept., General Electric Co., Schenectady, N. Y.

1. For references see Bibliography in unabridged paper.

Presented at the Middle Eastern District Meeting No. 2, Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

central hub to which are bolted radial steel arms; the hub consists of top and bottom plates between which are welded radial steel ribs. The fabricated arms are attached to the central hub by means of reamed bolts and also by plates at the top and bottom of each arm. A steel ventilating hood completely surrounds the frame.

Features of Stator Design

Welding and the use of rolled steel plate have progressed to such an extent that it is now possible to make

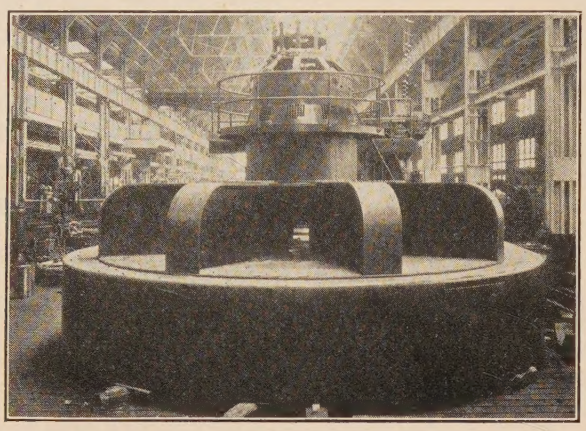


Fig. 5—33,000-Kv-A. 125-Rev. per Min. 6600-Volts 50-Cycle Generator with Practically No Castings

almost any size of frame, and by designing it in sufficient sections, to ship it to the installation without exceeding permissible weights or clearances.

The novel frame design of the 26,667-kv-a. generators for the Central Maine Power Company, (Fig. 7), illustrates the flexibility of fabricated construction.

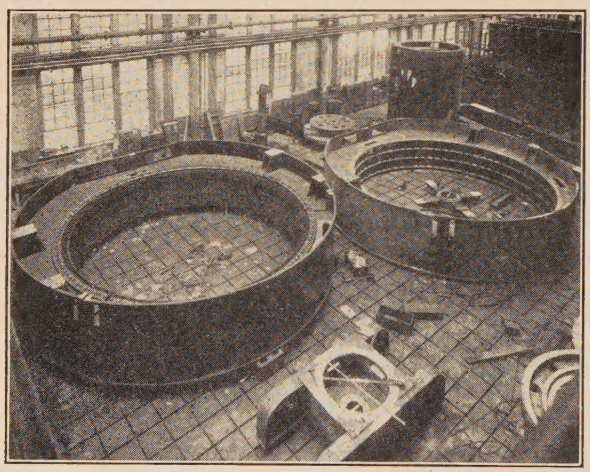


Fig. 7—Eccentric Stator Frames

For 26,667-kv-a. 138½-rev. per min. 13,800-volt vertical generators

The frame when viewed from the outside is of conventional circular shape but the air-gap circle is eccentric to the outside, thus giving a volute form of ventilating air space behind the laminations. The design permits the collection of air from the stator ducts around the entire periphery; also its complete discharge from one side of the frame, thus simplifying station duct work and construction. This design has obvious advantages over the use of a standard concentric frame with external eccentric ventilating hood.

Features of Rotor Design

Fig. 8 shows the rotor spider of the 33,000-kv-a. generator, and Fig. 9, the assembled rotor. The center

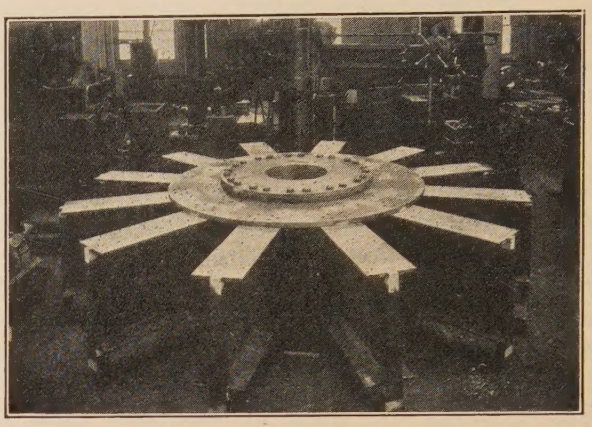


Fig. 8—Rotor Spider

For 33,000-kv-a. vertical generator

spider is a fabricated structure consisting of I-beams bolted between circular plates. The rim is made of segmental, punched laminations, mounted on the center spider. The segments are punched for pole-piece dovetail rim key, and for through bolts for clamping

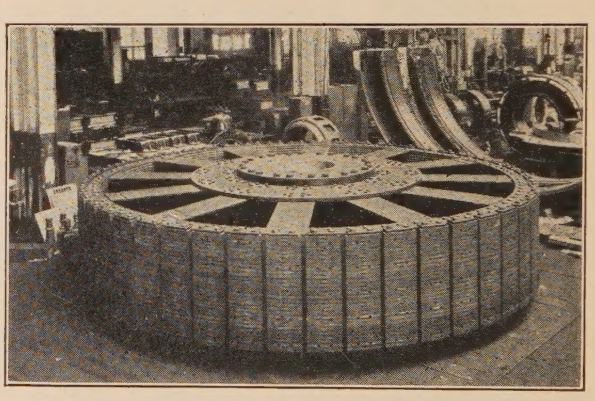


Fig. 9—Fabricated Rotor with Laminated Rim

For 33,000-kv-a. vertical generator

the core. At the end of the rotor spider arms are welded, vertical ribs slotted to receive the rim keys.

In this design the rim is not anchored to the rotor spider but the torque is transmitted through axial keys which fit into notches in the rim punchings and slots on the spider arm ribs. This leaves the rim free to expand under centrifugal stresses without transferring any stress to the spider, thus making the design of the rim and the spider independent and their stresses definite. When rim and arms are rigidly fastened together, the radial arm tension and the peripheral rim

tension divide the total stresses in inverse ratio to their elastic deformations. The uncertainties thus introduced are avoided in this new design. A similar free rim construction was used in the Conowingo generators.[3]

Fig. 10 shows a 10,000-kv-a. 180-rev. per min. 13,800-volt vertical hydroelectric generator rotor with poles completely assembled. A new type of braking surface, consisting of machined segmental plates attached to the rotor spider arms by means of tapped bolts, is clearly shown. The air or oil-operated brakes

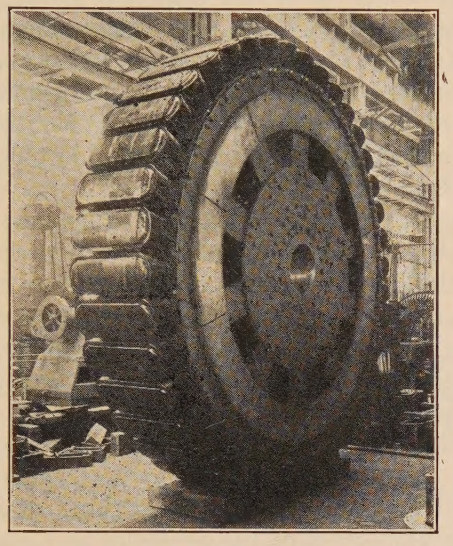


Fig. 10—Assembled Rotor Showing Segmental Braking Plates

For 10,000-kv-a. 180-rev. per min. 13,800-volt vertical hydroelectric generator

act against this surface to stop the rotor in case of gate leakage.

The largest rotor spider fabricated up to the present time is shown in an inverted position, in the process of machining the segmental braking plates in Fig. 12. The outside diameter of these plates is nearly 29 ft., exceeded in size only by the rotors of the 77,500-kv-a. generators being built for the Dnieper River Project.

In view of the thrust bearing being located beneath the rotor spider, the arms are designed with a downward curve so as to make the center line of the laminated rim considerably below the center line of the hub. The web plates of these arms are flame-cut to the desired shape, to which shape the top and bottom plates are formed and welded to the web plate; to give additional rigidity, ribs or stiffening plates are welded to each side of the web plate. The eleven arms of the rotor are bolted to thick steel plates at the top and bottom of the arms by means of body-bound bolts; the plates are attached to the steel spider hub by body-bound stud bolts.

Overhung Vertical Generators

In recent years there has been an increasing tendency toward the adoption of the overhung type of vertical generator. The outstanding advantage of this type is the reduction of over-all height which allows a corresponding reduction in height of crane; the chief disadvantage is the free length of shaft above the bearing, and the consequent possibility of vibration at high speeds. The design is well suited to low-speed generators but is not applicable to machines in the highest speed range.

Some of the first machines of this kind manufactured by the company with which the author is associated were built seven years ago and are rated 8200 kv-a., 150 rev. per min., 6600 volts.

Since that time, a large number of machines of this type has been built. The largest in physical dimensions, (which is now being built for the New York Power and Light Co., Spiers Falls, N. Y.), is rated 47,000 kv-a., 81.8 rev. per min., 13,800 volts. This generator will be driven by a Francis type waterwheel rated 57,000 hp. It will require 6200 sec-ft. to operate it at full load, or the entire flow of the Hudson River during low water period. The net head is 81 ft.

The thrust bearing for this machine is located just below the rotor spider. It is the largest combined guide and thrust bearing ever manufactured, is 84 in. outside diameter, and will carry a total weight of 1,365,000 lb., of which 815,000 lb. is the combined weight of waterwheel runner and shaft and hydraulic

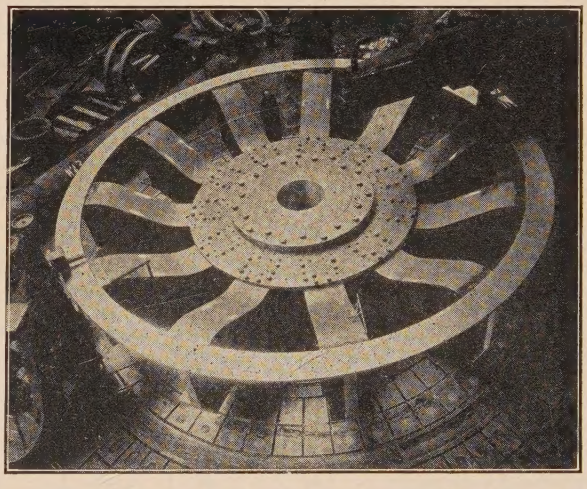


Fig. 12—Rotor Spider in an Inverted Position in the Process of Machining the Segmental Braking Plates

For the 47,000-kv-a. generator

thrust. The guide bearing is 52 in. diameter by 26 in. in length. To facilitate inspection the stationary ring, rotating ring, and guide bearing are all split.

Dnieper River Generators

For the Dnieper River Project there are now being constructed the world's largest type of hydroelectric generators, rated at 77,500 kv-a., 88.25 rev. per min.,

13,800 volts, 50 cycles. Five of these machines are being built and when completed this plant will have nine generators, each driven by 84,000-hp. waterwheels—the largest hydraulic turbines ever built. The average operating head is 116.5 ft. The ultimate installation will be 750,000 hp., and it is expected that the plant will be completed by 1934.

Fig. 17 shows a perspective of this immense installation at Kichkas, Republic of Ukraine, which has been furnished through the courtesy of Colonel H. L. Cooper, the consulting engineer on this project. The construction of locks and the raising of the water level of the Dnieper River will make it navigable for 1500 mi.

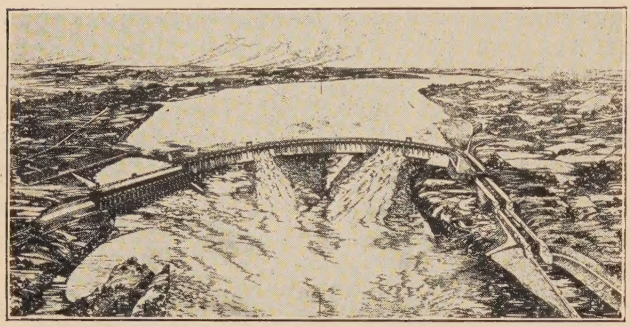


FIG. 17—PERSPECTIVE OF THE DNIEPER RIVER PROJECT AT KICHKAS REPUBLIC OF UKRAINE, RUSSIA

An idea of the proportions of these generators is given by the following comparison of their principal weights and dimensions with those of the largest American and European[4] machines heretofore built:

	Dnepro-stroy	Niagara	Spiers Falls	Ryburg-Schwor-stadt
Date completed	1931	1923	1930	1929
Kv-a. rating	77,500	65,000	47,000	35,000
Speed in rev. per min	88.2	107	81.8	75
Frequency in cycles	50	25	60	50
Voltage	13,800	12,000	13,800	10,500
Power factor	0.8	0.8	0.8	0.7
Outside diameter—ft	41	31	37	44
Over-all height from bottom of stator frame to top of machine—ft	26	27	16	..
Height from face of coupling to top of machine—ft	41	27	24	32
Weight of rotor—lb	978,000	785,000	540,000	..
Total weight—lb	1,740,000	1,517,000	976,000	1,210,000

These Dneprostroy machines will be of the conventional type with thrust bearings located in the upper bearing brackets. There are two guide bearings—one beneath the thrust bearing and one in the lower bearing bracket.

The General Electric thrust bearings used on these machines are the *largest ever designed*, having an outside diameter of 92 in. and an inside diameter of 31 in. The total weight carried on a bearing is 1,900,000 lb. including the weight of waterwheel, waterwheel shaft, and hydraulic thrust.

FUTURE POSSIBILITIES

It is interesting to speculate as to the possibilities of the future:

In respect to capacity, it is clear that the limit has by no means been reached. There is no reason why generators of 150,000-kv-a. rating, at speeds of 150 rev. per min. or less, cannot be built if they are needed; it is extremely probable therefore that the present trend toward larger capacities will continue.

In respect to voltage, it is feasible to build generators of normal design for 24,000 volts and higher, although there is no present demand for voltages much in excess of 15,000 volts. At the transmission voltages employed by large stations, the use of transformers is now imperative; and so, the choice of generator voltage is based on considerations of station equipment rather than transmission. In large stations it may be found economical to generate at 22,000 volts, but it seems more probable that lower voltages will continue to be used, while double windings[5] and unit operation of transformers and generators will be brought in to reduce the switching requirements and improve stability.

The generator speeds required with present hydroelectric practise, except in very high-head developments, seldom bring in any mechanical limitations; therefore the speeds of future waterwheel generators will be limited by considerations of turbine design. The recent developments of the propeller and Kaplan turbines,[6] making it possible to use higher-speed wheels in low-head plants, will create a tendency toward higher speeds and make feasible the developments of very low-head plants.

An interesting possibility of the future is the use of multi-speed generators to permit efficient use of the water under varying conditions. Propeller type turbines with adjustable pitch blade can be set to give the greatest efficiency under the actual operating conditions. By designing the generator for pole changing, however, a similar effect can be obtained electrically. Two-to-one pole changing is well known but it gives too great a speed change for normal conditions. Recently, a three-to-two speed salient-pole synchronous motor has been built which gave satisfactory performance at both speeds without great sacrifice of characteristics at either speed. The same design can be applied to a hydroelectric generator, making it possible to develop power at a fixed frequency and voltage with either full or two-thirds speed.

The overhung type of vertical hydroelectric generators will likely increase in popularity.

Fabricated construction will continue without doubt until all important hydroelectric generators are so made. With increasing appreciation of the flexibility of design made possible by this development, it is probable that there will be a strong tendency to adapt the generator frame design to the power house. The final result of this trend may well be the adoption of outdoor generator designs, of which several are under consideration.

Abridgment of

Control Systems for Oil- and Gasoline-Electric Locomotives and Cars

BY N. L. FREEMAN[1]

Associate, A. I. E. E.

Synopsis.—*A review is given of the development of self-propelled railway vehicles which utilize electrical transmission, paying particular attention to the ways and means of regulating the torque demand on the internal combustion engine which serves as the source of power, and the supply of power to the auxiliaries.*

Two general designs are discussed and classified as "differential field control" and "torque control." In differentiating between these two systems, two types of differential field control are outlined, giving their major advantages and limitations. The principle of torque control depending upon constant engine speed is discussed, with enumeration of its advantages over previous schemes, permitting as it does the absorption of the entire engine output for any throttle opening and engine speed selected.

The differential field control comprises the minimum amount of apparatus consistent with operation of the car or locomotive and its auxiliaries. In connection with this type of control, however, it should be noted that battery charging and air compressor operation cannot be obtained at both operating and idling speeds of the engine.

Torque control equipment functions to vary automatically the generator voltage inversely as the current in such a way that the full available power of the engine is utilized; it acts directly on the generator field and has proved its superiority over methods of regulation involving the exciter field. The availability of the auxiliary generator for compressor operation and battery charging when the engine is running under load represents a marked advance in design. The main generator supplies these auxiliaries during idling. The torque control system meets the requirement of any type of engine.

* * * * *

Introduction

SELF-PROPELLED railway vehicles driven by internal combustion engines have a brief history of about 30 years. Those using electrical transmission outnumber all other types.

From the beginning, the electrical transmission for commercial railway vehicles has included a generator, and traction motors. Practically all the traction motors have been of the series type, the input to such motors being a function of speed and applied voltage. As overloading an internal combustion engine will cause it to run at a lower speed or stop it entirely, it was necessary to protect against such a condition. In 1924 and 1925 this was done by means of a differential field for reducing the main generator voltage with an increase in current demand. The differential field was placed on the exciter because it produced more favorable characteristics and was a much less expensive winding.

There were two distinct methods of applying this differential winding: One designer distributed the winding to all poles in the exciter and proceeded to charge the battery from the exciter through a field on the main generator; (this system supplied the usual drooping characteristic with fairly sharp voltage regulation with respect to engine speed, Fig. 1A). Another designer concentrated the differential winding on two of the exciter's poles. The battery was charged from the exciter, but through an external resistor instead of a field. This concentration of winding gave more than the usual drooping characteristic. With less sharp regulation of engine speed, its power requirement was much more uniform over the range of car speeds. (Fig. 1B.) Both systems were widely used and with improvements in design are still being applied.

In all of the equipment, the auxiliaries presented a serious problem; as the representative source of air-brake supply, lights, battery charge, and radiator air supply, and being operated by means of the main generator, their operation was dependent upon the engine and car speed simultaneously, and the results were none too satisfactory. This was particularly true when the profile contained grades which required slow, steady pulling in one direction and a long drift in the other. Under these conditions battery charge and air supply offered the most serious problems.

In order to improve the operation of auxiliaries and the loading characteristic in general, a system of torque control was introduced. The equipment using this system had its loading characteristic controlled by a regulator which varied the main generator field. This regulator limited to a selected value the torque load impressed on the engine, with a simple hand lever adjustment on the regulator spring for selecting the torque required. In this scheme, the exciter became an auxiliary generator and supplied a battery charge under almost any loading condition. A low-voltage compressor operated from this source, and in addition, the battery and compressor were supplied current through the starting connections from the main generator during idling. This equipment was arranged to use the main generator as a starting motor. All of this is shown in Fig. 2. This equipment, with its definite and effective loading characteristic, overcame many of the early problems, and was especially effective with the more rugged profiles and irregular schedules, re-

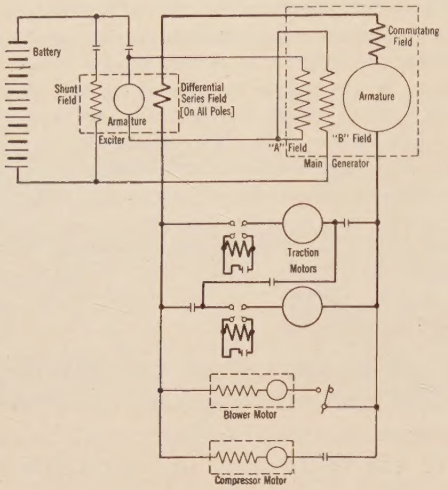
1. Rwy. Equip. Engg. Dept., Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Presented at the Summer Convention of the A. I. E. E., Toronto, Ontario, Canada, June 23-27, 1930. Complete copy upon request.

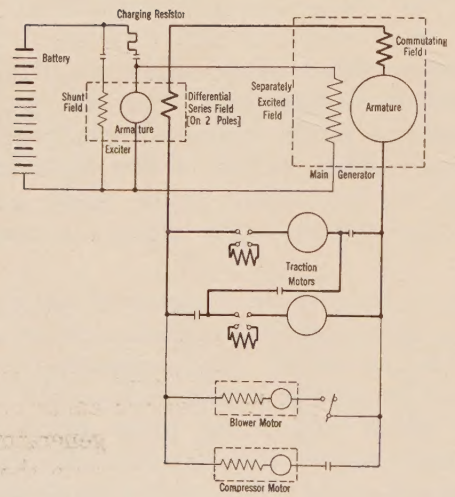
moving several of the natural handicaps under which these cars and locomotives formerly operated.

Required Fundamentals

The success of the torque control system led to further improvements which enabled it to cope automatically with variation in the engine output characteristic. Fig. 3 shows a test curve of one engine with respect to its rating.



A



B

Fig. 1—Differential Exciter Scheme of Control

A—Using a distributed differential winding on the exciter and the "B" field on the main generator

B—Using a differential field concentrated on two poles of the exciter

Obviously either the engine torque must be matched with its load or the load with the available engine torque. If the required engine size is to be a minimum, its revolutions conserved, and the economy kept at the most desirable value, *the load must be fitted to the torque available.*

The ideal loading is that which regardless of engine condition will hold the engine to a selected speed. Such a system of loading permits the absorption of the entire output of an engine for any throttle opening or speed selected. That, however, is beyond the scope of performance of differential or definite characteristic machines, since the ideal loading is predicated on an engine's ability to maintain its speed.

Torque Regulation from Speed

The original method selected for measuring engine speed was to express the speed in terms of voltage from a

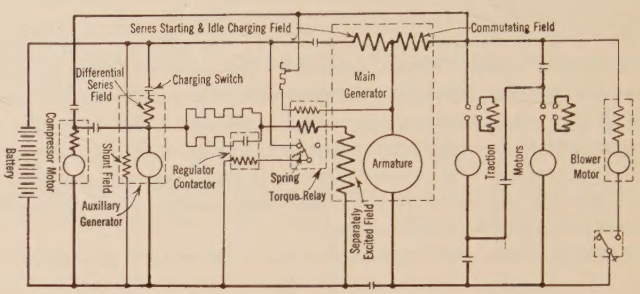


Fig. 2—External Regulator Scheme of Control, Limited Torque System

small control generator of constant field strength. Because of the constant field strength, this voltage would then be proportional to the generator speed. The control generator was belted to the engine, making its voltage also proportional to engine speed. This voltage was then applied to a sensitive voltage relay which operated a contactor in the main generator field. The contactor when open gave the minimum field strength required, and when closed, the maximum field

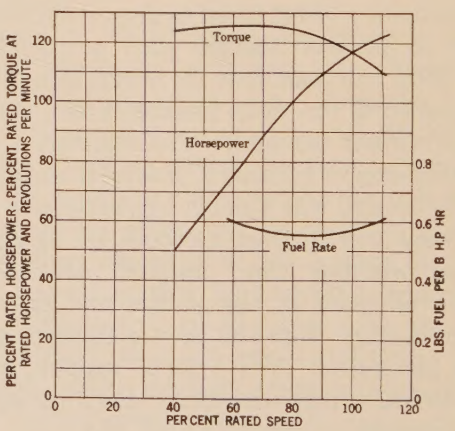


Fig. 3—A Typical Gasoline Engine Performance Curve

strength. (See Fig. 4A.) Since large power surges originate within it, such a system is not stable; but stability was obtained by recalibrating the voltage relay in step with the regulating switch, which is shown in Fig. 4C and a discussion of this method appearing in Appendix II.

It was but a short step from the control generator to an exciter, or an auxiliary generator for the combined duties of both. Since the regulation was for a speed almost constant, the auxiliary generator voltage would be

at a nearly constant value for each selected speed. The battery therefore is charged through a ballast or cushion resistor. This is a tapered charging system and commonly known as the modified constant-potential system.

The use of this type of charging system permitted the introduction of another feature; the charging

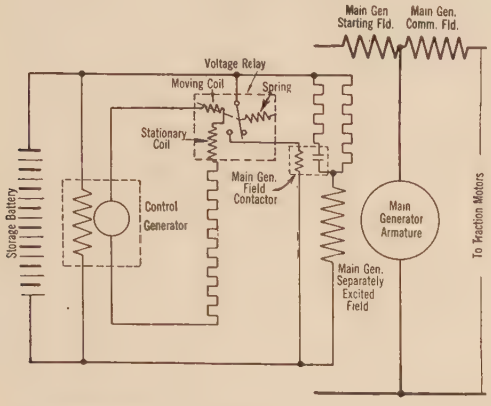


Fig. 4A—Elementary System for Regulating Torque from Speed. (Unstable)

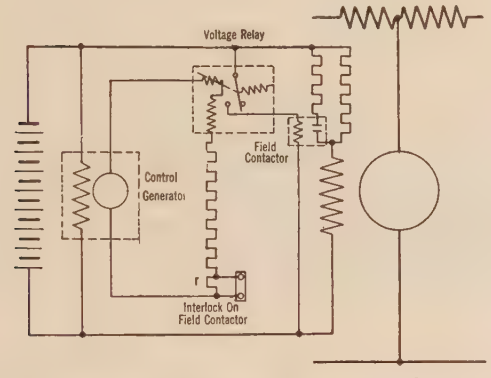


Fig. 4B—Interlock Method of Stabilizing Speed—Torque System

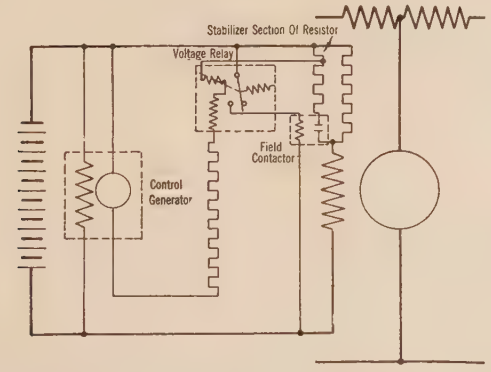


Fig. 4C—Resistor Stabilized System of Regulating Torque from Speed

resistor is of very low value—a fraction of an ohm; by connecting the charging switch between this resistor and the auxiliary generator, and the shunt field across the battery through this resistor as shown in Fig. 5, the field, while the charging switch is open, is battery-excited; as soon as it closes, the auxiliary generator becomes shunt-excited. This feature has an important result: For all practical purposes, the system is independent of battery condition; and more, the already narrow regulation speed band is narrowed still further.

This system of regulation also removes one of the objectionable features of electrical transmissions, which is that the loading characteristic of the electrical equipment changes considerably with temperature. Resistance variation effects due to temperature are in this scheme therefore so reduced that in the routine of service, the effects of temperature do not appear.

The theory of torque control from speed is sound; as developed, it is also simple. As a result, a simple, effective scheme has been constructed, allowing the operator to select the speed at which he desires to operate the engine, the control system insuring the engines being effectively loaded at that speed.

Special Features

As stated in the beginning, auxiliaries present an important problem. For the auxiliary power source during running, the constant voltage source of the auxiliary generator is almost ideal; during idling, the

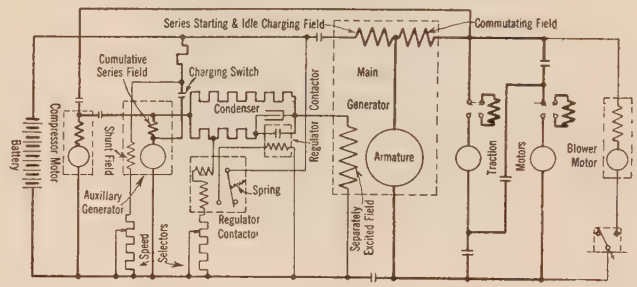


Fig. 5—External Regulator Scheme of Control, Torque Regulation from Speed System

main generator is used through the starting connections for charging the battery and operating the auxiliaries; and being charged through a differential series field, the battery regulates the main generator voltage. This provides a source of auxiliary power for the remainder of the engine's operating cycle.

In the third regulating system described, (Fig. 2), a transition was developed which was distinctly one for self-propelled equipment. It is also used in the new system, and is a closed transition. The operation is accomplished by opening the regulator switch, closing one parallel switch, opening the series switch, and closing the other parallel switch, all in succession and followed by the closing of the regulator switch. This transition is made with no noticeable change in engine speed and without noticeable vehicle surges, thus indicating a continuous accelerating rate.

Field Tests

After this system had been well tested in the laboratory, a test car was built and equipped with a large gasoline engine, generators, control, and motors. Again the system was thoroughly studied and improved as suggested by the tests. As this indicated a successful scheme, arrangements were made with the Baltimore and Ohio Railroad to equip a car with

similar control. This car operated over a branch line in West Virginia, and from the beginning, the installation was a decided success. A car which was almost ready for shopping stayed in service for 50 per cent more mileage and showed a better operating record than ever before.

The chief characteristics of the changed performance were the buoyant operation of the engine and the excellent car-accelerating characteristics. With the engine loaded by this scheme, it very promptly came up to speed and there was a smooth continuous flow of power from the time the engine attained the speed selected by the operator until he shut it off. There was

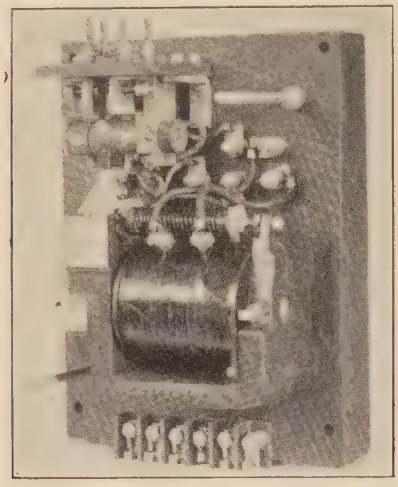


Fig. 6A—Regulator Relay

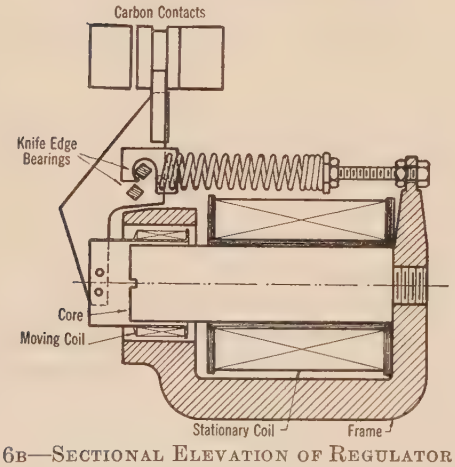


Fig. 6B—Sectional Elevation of Regulator Relay

no complicated handling involved, and men unfamiliar with the new equipment had no trouble in operating and maintaining it.

Summary

Since the beginning of the history of self-propelled cars and locomotives, electrical transmission has been used extensively; but all previous systems have appeared to have their common or special faults. Now a simple system using speed as an indication of engine torque has been developed, suiting the torque applied to the engine to whatever torque the engine is able to develop at a selected speed and throttle opening, regardless of the condition of the engine at that time. If one cylinder does not fire, the load is decreased accordingly; but the speed remains the same. This enables the operator to utilize the maximum horsepower the engine can develop at any time, which is of vital importance on a car or locomotive with a limited power plant.

Additional features of continuous power supply for battery charge and compressor operation and an improved closed transition are used. The scheme has been thoroughly tested with entirely satisfactory results.

Appendix II

A voltage relay across the control generator arranged for operating a contactor in the main generator field presents a problem. This problem is hunting, and it was to be expected, since a speed change affected only the voltage of the control generator. This voltage then operated the sensitive voltage relay; next the field contactor opened or closed and the field began to change. Eventually, the field value changed enough to reverse the speed change. In all, considerable time elapsed between the registering of the chosen speed and the final reversal of the speed change causing it. This

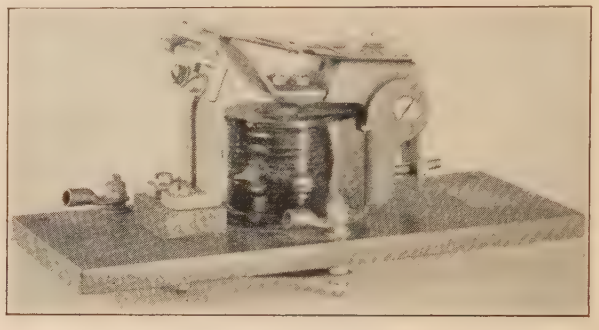


Fig. 7—Regulator Contactor

was confirmed by test. It was apparent that the time lag would have to be overcome by anticipating it, and this was accomplished by changing the relay setting as soon as the field contactor closed or opened. An interlock circuit on this switch was first used for this purpose and resulted in the stabilization of the circuit. (Fig. 4B.)

The introduction of this method of stabilization altered the character of the regulation, a condition which becomes apparent by considering the resistance value r as varied from zero up to higher values.

At the zero value of r, the hunting is at its worst. With each increment of r, the system responds in a shorter time. Thus, the circuit operations become more and more self-energized. Such a system can be quickened to the point where it is entirely self-energized and there are no speed pulsations. For its source of energy, however, it depends on speed although it originates its own impulses.

The relation between proper time, in and out, for the field contactor (or main generator field strength) and the main generator load, would appear to have no connection with the regulating system. This, however, is not true, for if the average field is too low to cause

adequate loading, the engine speed will increase. A slight increase in speed increases the voltage on the control generator. The pulsating system then works between two slightly higher values, the ultimate result being that the regulator switch, or field contactor, stays closed a longer interval of time and open a smaller percentage of time. This will raise the average field value which will in turn increase the loading and hold the engine to a speed slightly higher than before. Tests have shown that the regulating band thus incurred is narrow.

An interlock on the regulator switch is not desirable; therefore the pulsating characteristics of the field circuit were used for the same duty. A resistor in series with the regulator switch results in less current through the switch and is unaffected by field discharge action. (Fig. 4c.) Consequently a small voltage drop from this resistor was used instead of the regulator switch interlock, which again altered the pulsating characteristics of the circuit. They now depend upon two things,—the natural speed that would exist with the interlock system, and the building-up characteristics of the main field. The natural speed of closing determines approximately the time of the reclosing of the field contactor, and the rate with which the field current builds up determines the time elapsing before the switch reopens. Since the field responds very slowly to such changes, the system is always exactly in step with it, yet its pulsating rate is greatly reduced. (Refer again to Fig. 4c.)

Abridgment of

Corona Loss Measurements
on a 220-Kv. 60-Cycle Three-Phase Experimental Line

BY JOSEPH S. CARROLL,* Associate, A. I. E. E. LELAND H. BROWN,† Associate, A. I. E. E. and D. P. DINAPOLI‡ Associate, A. I. E. E.

Synopsis.—*Corona loss measurements were made on seven different conductor specimens. The losses were measured directly on a three-phase line 700 ft. long by means of three single-phase high-voltage wattmeters. The object of the test was to obtain data for the choice of conductor to be used on a 220-kv. 60-cycle line. The results show the effect of weathering conductors, the comparison of conductors of two different diameters, the effect of size of strands, the method of stranding, and also the effect on new conductors of the change in surface conditions caused by rain and washing.*

* * * * *

Introduction

THE purpose of these corona loss measurements, made at the Ryan Laboratory, Stanford University, was primarily the comparison of different conductors for use on a 220-kv. transmission line. Among the things that were to be studied was the effect on corona loss of the different methods of stranding, size of strands, the spacing and configuration of conductors, the difference between a conductor 0.91 in. in diameter and one 1.0 in. in diameter and also the difference, if any, between copper and aluminum conductors.

Description of Equipment

The test line was 700 ft. long, and the conductors were supported between steel masts as shown in Figs. 1 and 2. With this arrangement, the conductors to be tested were laid out on the ground, fastened onto the insulator strings, and raised into position by means of winches, one on each mast.

The shielded leads from the building to the test specimen were hollow concentric-lay aluminum conductors 1.1 in. in diameter. At the time this cable was made, two No. 12 rubber-covered copper wires were placed on the inside of the cable. These two wires were used as the lead from the wattmeter to the test specimen.

The line was energized by means of three 350-kv., 350-kv-a. transformers which were connected delta on the low-voltage side, and Y on the high-voltage side with the neutral grounded. The source of power for these transformers was a 1500-kv-a., 60-cycle sine-wave motor-generator set. The voltage was controlled by means of a rheostat in the exciter field. The root-mean-square value of the line voltage to ground was obtained by means of the voltmeter coil in the transformers. With the line connected, the reading of the voltmeter across this coil was checked against the voltage from line to ground as measured with a sphere-gap. The agreement was within one per cent. Measurements with a harmonic analyzer showed that the third harmonic was the greatest, and at 260 kv. this was less than one per cent.

The corona loss at 60 cycles was measured directly by means of three high-voltage wattmeters, one connected in on each conductor. The diagram of connections of one of the wattmeters is shown in Fig. 3. Each wattmeter assembly was almost identical with that described in a former paper.[1]

The milliammeter that measured the current through

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1. See Bibliography for all references.

the water resistor wattmeter multiplier was connected in the ground side of the resistor. A three cylinder piston pump supplied water to all three resistors. The use of salt water for changing the resistance of the multiplier was the same as in the former set-up. The shielding cages containing the wattmeter instruments

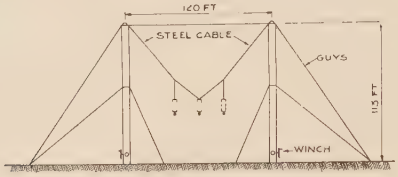


FIG. 1—TRANSVERSE SECTION OF TEST LINE

were mounted directly on top of the upper shields of the water resistors. The meters were read by means of telescopes from platforms directly above.

SHIELDING

The shielded lead from the wattmeter to the test conductor was 440 ft. long. The capacitance between

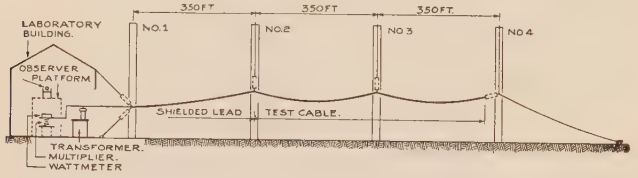


FIG. 2—LONGITUDINAL SECTION OF TEST LINE

this lead and its shield was 0.04 μf. This capacitance shunts the field or current coil of the wattmeter and due to the low power factor of these measurements, the current through this capacitance would shift the phase angle of the current through the field coil of the wattmeter and cause serious error. This capaci-

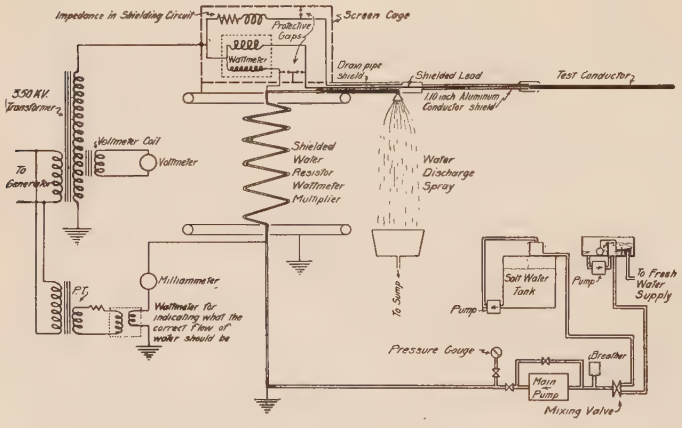


FIG. 3—WATTMETER CONNECTIONS

tance cannot be eliminated; however, if the potential of the shield is made the same as that of the lead, there can be no flow of current through the capacitance. This was accomplished by inserting an impedance in the shielding circuit, as shown in the diagram of Fig. 3. The constants of the impedance in the shielding circuit were obtained as follows: The charging current to the test specimen was measured, as was also the charging current to the shielding circuit. The inverse ratio of these currents gives the ratio of the impedances in these two circuits; the resistance and inductance of the current coil of the wattmeter are given by the maker. With the above information, coils were designed and made up for the three shielding circuits.

CORONA LOSS ON DIFFERENT CONDUCTORS

The first conductor tested was a 0.91-in. diameter rope-lay weathered copper cable. This conductor had

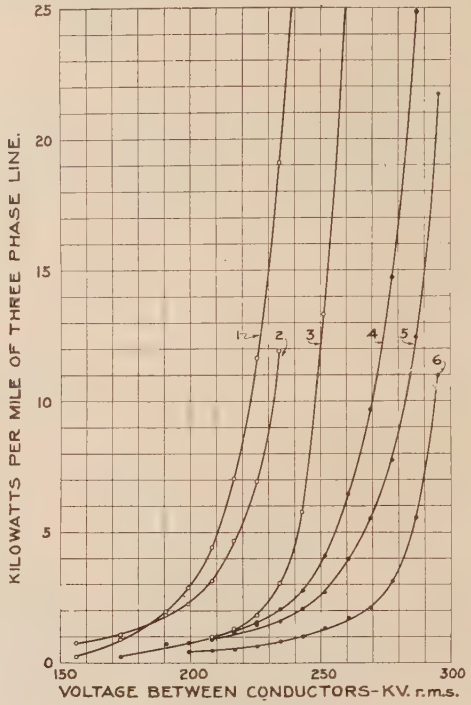


FIG. 4—CORONA LOSS CURVES

CONFIGURATION—20 FT. HORIZONTAL BY 30 FT. MIN. TO GROUND

Curve No.	Conductor	Date	Humidity per cent	Temp. deg. fahr.	Barometer in. hg.	Remarks
2	0.91 in. rope lay copper weathered	Mar. 31, 1930	63	53	29.85	
1	0.91 in. rope lay copper new	Apr. 30, 1930	36	72	29.68	Before washing
3	0.91 in. rope lay copper new	May 1, 1930	52.5	67.5	29.90	After washing
4	1.0 in. steel core aluminum weathered	May 29, 1930	40.5	65	29.91	
6	1.0 in. steel core aluminum unused	May 23, 1930	35	80	29.94	After washing
5	1.0 in. steel core aluminum unused	May 26, 1930	57.5	63.5	30.01	After washing

been in use for several years on the 220-kv. Pit River line of the Pacific Gas and Electric Co., a section 2200 ft. long having been taken off the line especially for this test. As the conductor was removed from the towers, it was carefully wrapped with strips of burlap in order to preserve the condition of its surface. In raising the conductor on the test line, the burlap was not removed until the conductor had cleared the ground. To aid in

the determination of the change in corona loss due to weathering, a new conductor of the same kind was next tested. (See Fig. 4)

It should be noted that for all the loss curves given in this paper, except those in Figs. 9 and 10, the corona loss per mile of three-phase line is plotted as a function of the voltage between lines. The loss per mile of line was chosen in preference to the loss per conductor mile because the loss on the three conductors is not the same; another reason is that the engineer usually thinks of a three-phase line as a unit.

The next tests were on a new two-layer concentric hollow copper cable 0.91 in. in diameter, and a new two-layer concentric hollow copper cable 1.0 in. in diameter. While this latter conductor was in place, it rained during the night. A few measurements were made during the rain the next day and some immediately there-

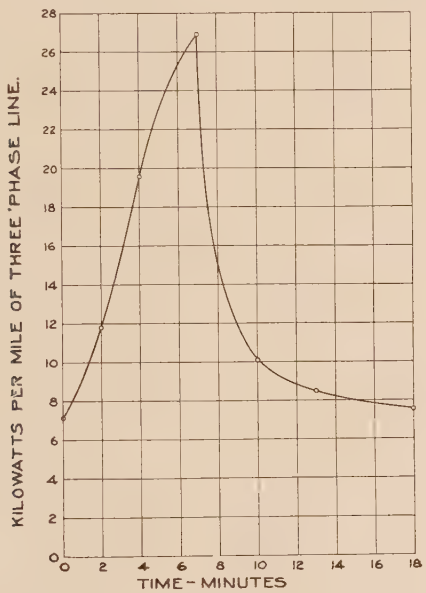


FIG. 5—CORONA LOSS DURING SHOWER AT 220 KV. BETWEEN LINES.

Conductor— 1.0 in. hollow concentric two layer copper
Date— April 14, 1930
Humidity— 100 per cent
Temperature—58 deg. fahr. (taken in the laboratory)
Barometer— 30.05 in. hg.

after; the losses during the rain were rather high but the rainfall was not sufficiently steady to obtain a good loss curve. The curve in Fig. 5 shows the variation in loss at 220 kv., from the beginning to the end of a short shower; no measurement was made of the rate of rainfall. The loss measurements made on this conductor the day after the rain showed the loss to be much higher than before the rain. (See Curves 1 and 2, Fig. 6) Evidently some change had taken place on the surface of the conductor; the new copper conductors were somewhat greasy—apparently left that way from some process of their manufacture. Since the rain had made such a definite increase in the losses on the new conductor, it was decided to see what effect washing it would have. The process of washing was as follows: The line was lowered and the conductors were supported on wooden horses. The cables were then scrubbed with gasoline, the excess gasoline being wiped off and the rest allowed to evaporate. This was followed by a scrubbing with soap-suds which were washed off by means of a cloth and plenty of clean water. To remove any further traces of soap that might be left, the conductors

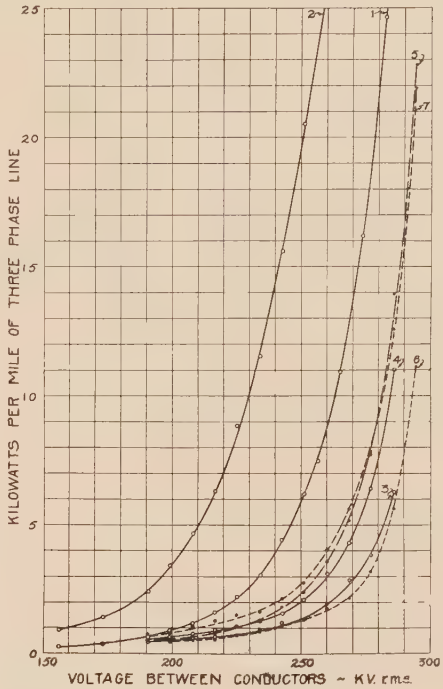


FIG. 6—CORONA LOSS CURVES

CONFIGURATION—20 FT. HORIZONTAL BY 30 FT. MIN. TO GROUND

Curve No.	Conductor	Date	Humidity per cent	Temp. deg. fahr.	Barometer in. hg.	Remarks
1	1.0 in. hollow concentric two layer copper	Apr. 11, 1930	45	69	29.96	Before washing
2	1.0 in. hollow concentric two layer copper	Apr. 15, 1930	59	63.5	30.05	After rain
3	1.0 in. hollow concentric two layer copper	Apr. 23, 1930	52	68	29.90	After washing
4	1.0 in. hollow concentric two layer copper	Apr. 28, 1930	59.5	62.5	30.00	After washing
5	1.0 in. steel core aluminum (unused)	May 21, 1930	26.5	69.5	30.16	Before washing
6	1.0 in. steel core aluminum (unused)	May 23, 1930	35	80	29.94	After washing
7	1.0 in. steel core aluminum (unused)	May 26, 1930	57.5	63.5	30.01	After washing

were again washed with running water and scrubbing brushes. The line was then raised into place and when dry, was tested.

The surprising thing was that while the rain had left this conductor in such condition that the losses were higher than those before the rain, the effect of the wash-

ing was to reduce the losses to less than those before the rain. (See Fig. 6) The condition of the conductor was carefully inspected before and after washing, and the only visible effect that the scrubbing seemed to have was to remove some of the stains which had been left by the rain. The strands of this particular

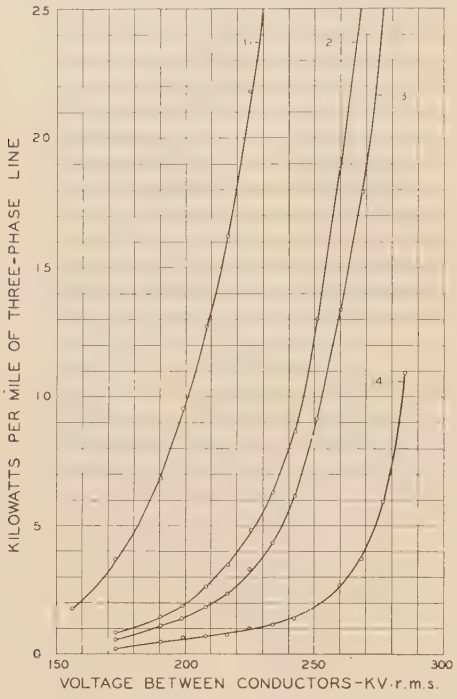


FIG. 7—CORONA LOSS CURVES

CONFIGURATION—20 FT. HORIZONTAL BY 30 FT. MIN. TO GROUND

Curve No.	Conductor	Date	Humidity per cent	Temp. deg. fahr.	Barometer in. hg.	Remarks
1	1.0 in. hollow concentric single layer copper	May 12, 1930	57	64	30.04	Before washing
3	1.0 in. hollow concentric single layer copper	May 14, 1930	60	60	30.02	After washing
2	0.91 in. hollow concentric two layer copper	May 7, 1930	46	60	29.99	Before washing
4	0.91 in. hollow concentric two layer copper	May 8, 1930	33	64	29.87	After washing

conductor were very free from slivers and burrs. A week later when the line was taken down, it was noted that the copper had oxidized much more rapidly after washing than before, indicating that the grease had been protecting its surface. Measurements made a few days after the conductor was washed showed a slight increase in losses above those measured immediately after washing. (See Curve 4 of Fig. 6)

The other two new conductor specimens, the 0.91 rope-lay and 0.91 concentric that had already been tested and taken down, were again put up and tested, lowered, and washed in the same manner just described; then raised and tested again. The results are shown in the curves of Figs. 4 and 7. The next conductor to be mounted on the line was a single-layer concentric, hollow copper cable 1.0 in. in diameter. The strands of which this conductor was composed were rather large; apparently during manufacture, they had been scored, leaving slivers and burrs on the finished cable which made impossible a fair comparison between this conductor and the other one-inch copper conductor made up of smaller strands. It is interesting to note that the losses on this conductor before washing were much greater than any of the others. Washing greatly reduced the loss; however, it was still high. (Fig. 7.) Just how much of this increase in loss above that of the other one-inch concentric copper conductor was due to the larger strands of which the cable was composed is still a question, because while the process of washing removed practically all the slivers, the strands themselves were still rather badly burred.

The next specimen tested was a new concentric-lay aluminum conductor 1.0 in. in diameter. This cable was not in quite the same condition as that in which

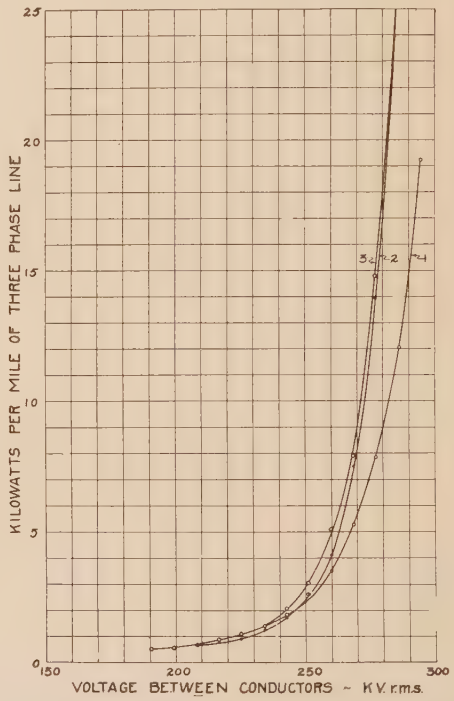


FIG. 8—CORONA LOSS CURVES—DIFFERENT CONFIGURATIONS

CONDUCTOR—1.0 IN. STEEL CORE ALUMINUM (WEATHERED)

Curve No.	Configuration	Date	Humidity per cent	Temp. deg. fahr.	Barometer in. hg.
1	20ft. hor. by 30ft. min. to gr.	June 4, 1930	35	77.5	30.00
2	15ft. hor. by 30ft. min. to gr.	June 5, 1930	28.5	89	29.96
3	15ft. vert. by 30ft. min. to gr.	June 6, 1930	30	83	29.83

it left the factory. Evidently no care had been taken in the handling before it had reached the laboratory. The cable was somewhat scratched and dirty, so that the loss curves are not exactly what they would have been for a similar conductor direct from the factory; however, when this conductor was washed, its condition was comparable with that of one-inch two-layer

concentric copper. From Curves 3 and 6 in Fig. 6 it can be seen that the loss on these two conductors immediately after washing was practically the same.

The next conductor tested was one like the above except that it had been in use on the Pit River line for several years at 220 kv. It was taken down at the same time and handled in the same way as previously described for the weathered rope-lay copper conductor.

Line Changes

Up to this time, all the tests had been made with all three conductors in the same horizontal plane with a spacing of 20 ft., a sag of 8 ft., and a minimum clearance to ground of 30 ft. The next test was with the weathered aluminum, with the conductors in horizontal configuration, having a spacing of 20 ft. at three different elevations beginning with 70 ft. clearance to ground, and followed by tests at 30 ft. and 20 ft. clearances. The losses with the line at these three elevations were practically the same, the differences being so small that it seemed unnecessary to show the three curves.

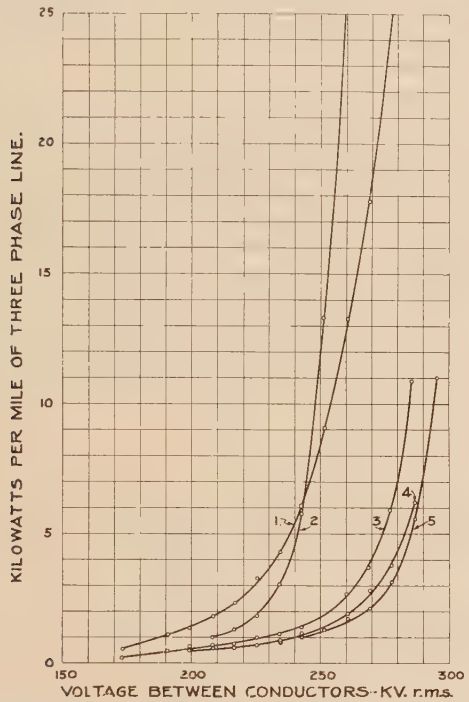


Fig. 9—Corona Loss Curves—Washed Conductors

CONFIGURATION—20 FT. HORIZONTAL BY 30 FT. MIN. TO GROUND

Curve No.	Conductor	Date	Humidity per cent	Temp. deg. fahr.	Barometer in. hg.
1	1.0 in. hollow concentric single layer	May 14, 1930	60	60	30.02
2	0.91 in. rope lay	May 1, 1930	52.5	67.5	29.90
3	0.91 in. hollow concentric two layer copper	May 8, 1930	33	64	29.87
4	1.0 in. hollow concentric two layer copper	Apr. 23, 1930	52	68	29.90
5	1.0 in. steel core aluminum used	May 23, 1930	35	80	29.94

The spacing between conductors was then changed from 20 ft. to 15 ft. with a clearance to ground of 30 ft. The results are shown in Curves 1 and 2 in Fig. 8. The conductors were then supported vertically all in the same plane with a 15-ft. spacing and a clearance to ground from the lower conductor of 30 ft. The loss curve is shown in Curve 3, Fig. 8.

As can be seen from the curves there is not much difference in loss for the different spacings and configurations.

Corona loss curves taken immediately after each of the five conductors were washed are shown in Fig. 9. It is believed that the surface conditions of the conductors were more nearly alike during these tests, and hence these curves offer the fairest comparison of the conductors.

The power factor computed for the line when the washed aluminum conductor was used was less than one-quarter of one per cent at 220 kv.

Conclusions

The results of the tests show that the corona loss on new cleaned conductors is the same for copper as it is for aluminum.

The effect of weathering the conductors as received from the factory was to decrease corona loss, while the effect of weathering new conductors after washing was to increase the loss.

Corona loss over the operating range of voltage of a 220-kv. line is affected only slightly by a considerable change in conductor spacing or configuration, or clearance to ground.

Until further tests are made, the use of strands as large as those of the one-inch single-layer hollow copper conductor on a one-inch conductor for 220 kv. will be questionable.

While the loss on the washed 0.91-in. hollow concentric copper conductor is very low at 220 kv., the use of such a cable is not recommended for a 220-kv. line because there is not sufficient margin to allow for the increased loss at higher altitudes and for the accumulation of dirt.

The losses on a rope-lay conductor are greater than on a concentric-lay cable of the same diameter.

The promised decrease in corona loss by washing a new conductor would seem to justify the removal of the grease on the conductor at the factory, rather than wait for the weather to do this at a considerable loss of power.

Acknowledgments

The authors are indebted to Doctor Harris J. Ryan for his helpful advice and suggestions.

The tests described in this paper were made possible through the cooperation of the Pacific Gas and Electric Company.

The hollow aluminum conductor used for the shielded wattmeter lead was donated to the laboratory by the Aluminum Company of America.

The three specimens of hollow copper conductor used in these tests were contributed by the Anaconda Wire and Cable Company and are to be left at the laboratory.

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Abridgment of

Forces in Turbine Generator Stator Windings†

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Synopsis.—*Experience has shown that the forces on turbine generator armature windings during short-circuit conditions are large, and that if adequate consideration is not given to the design of the coil bracing and support, windings may be seriously damaged.*

In this paper the forces are calculated for a particular case by the use of images, the change of flux interlinkages, and by the $\int H^2\,ds$ *over some surface in air which surrounds the conductor under consideration. A new and relatively simple proof is given for the validity of the latter method, the limitations and desirable applications of each method being considered.*

Forces on conductors in armature slots are computed with saturation both considered and neglected. Approximate formulas are derived for the forces on coil sides within one layer of the conical end winding, and for the straight coil extensions from the slots, with a numerical example given for each of these cases. The applicability of certain of these formulas to the phase connecting rings is pointed out, and the force on the entire conical surface of the end winding discussed qualitatively.

Certain desirable features of end winding bracing are mentioned, in most of these cases the instant considered being that following a line-to-neutral short circuit when the maximum possible instantaneous current is flowing.

I. General Discussion of Forces during Short Circuit

A. General Problem. It is the purpose of this paper to consider the maximum forces exerted in turbine generators on the various parts of diamond coil stator windings, conditions at the instant when the maximum possible instantaneous current flows in the armature winding on a line-to-neutral short circuit being given the most attention. A great deal of work has been done by previous investigators to establish methods for predetermining the magnitudes of the currents which result from instantaneous short circuits; the various cases, such as line-to-line short circuits, line-to-neutral short circuits, etc., have been considered in great detail, and much work has been published on the calculation of forces on bus structures and switches. However, it is believed that very little if any work has been published concerning the forces exerted on the windings of rotating machines during transient conditions.

A very brief consideration of the magnitudes of the short-circuit currents, and the proximity of these in the coil sides, will quickly convince one of the importance of their forces. Peak values of 50,000 amperes in parallel conductors with a spacing of about 1¾ in. from center to center of the coil sides is quite a reasonable possibility in well designed machines of only moderately large ratings.

Three things are necessary in the study:

1. The determination of short-circuit currents
2. The determination of the flux fields
3. Methods of calculating the forces exerted on the conductors after the currents and the flux fields are known.

The peak value of the armature current per coil side can be determined from the works of various authors.[1,2] In this paper it will be assumed that the armature currents can be computed with reasonable accuracy (see Appendix A, complete paper). The other currents, or perhaps it should be said magnetomotive forces, will be determined through the very useful principle applied by the same authors;[1,2] namely, that of the tendency for currents to flow in such directions as to maintain constant flux interlinkages in all the closed electric circuits in the metallic parts of the machine.

The flux distributions will be established by means of the relation $\int H'\,d'\,l' = 0.4\,\pi\,I$ (see Appendix B complete paper). The usefulness and applicability of this principle has been thoroughly demonstrated by the fairly accurate solutions of a number of the more important two dimensional flux fields in electrical machines.[3,8,12]

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†Taken from work presented for a Master's thesis under the University of Pittsburgh—Westinghouse Cooperative plan.

Presented at the Middle Eastern District Meeting No. 2, Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

1. For all references see Bibliography.

In this paper the forces will be calculated for two dimensional fields by one of three methods; each of these will be shown in detail later. The first is based on the use of images and the assertion that the force exerted between two parallel conductors is proportional to the product of the currents, to the length of the conductors, and inversely, to the distance between the conductors.[4,5] The second method is one which is very commonly employed; it is based on the rate of change in interlinkage (hence, of stored energy) with the displacement of a conductor, while the currents are maintained constant. The third method is based on the fact that the force on any current-carrying conductor existing in an electric field can be determined from $\int H^2\, ds$, taken over some surface surrounding the conductor.[6]

B. Division of Problem. The problem is arranged in parts according to the most convenient divisions of the flux fields. These will be taken up in the following order: 1. Forces on conductors in slots. 2. Forces within either layer of the conical surface of the end winding exerted on the sides of the coils. 3. Forces on the straight coil extension from the slot. 4. Forces on the phase connecting rings. 5. Forces on the whole conical surface of the end winding.

II. Detailed Discussion of Forces during Short Circuit

A. Forces on Conductors in Slots

In the study of the forces acting on the embedded portions of the armature conductors, there are three main problems to be considered:

1. Is the magnitude of the compressive force on the coil sides great enough to damage or rupture the insulation?

2. Are there repulsive forces between coil sides which might send a coil into the air-gap, carrying the stator wedge with it?

3. Are there forces which may rend the strands of one coil side?

Conclusions concerning the forces on conductors in armature slots:

1. The force pulsating at twice normal frequency and pressing the coils toward the bottom of the slot on a single-phase short circuit may have a value of 695 lb. per in. of conductor (or greater).

2. On three-phase short circuits in machines of less than full pitch there will be forces tending to drive a conductor out into the air-gap, carrying the wedge with it. These forces, while less than those just mentioned above may be very serious if a coil is loose so that the forces on the wedge arrive as impact blows.

3. The forces exerted toward the sides of the slot are very much less and exist only when the saturation in two adjacent teeth is appreciably different.

4. There are no electromagnetic forces acting directly to disrupt the conductors by separating the strands from one another. However, if the conductor is loose, the hammering of the conductor on the bottom of the slot may cause some internal motion which might be capable of wearing out the insulation between the strands very quickly.

B. Forces Within the Conical Surface of the End Winding

Fig. 12 indicates the approximate paths of the flux linking the armature end winding on a single-phase line to the neutral short circuit. All currents in the parallel conductors are in the same direction, so that these coil sides tend to pull together. The maximum force will be exerted on the inside conductor at sections X-X, because the greatest concentration of flux is in this elbow of the phase group. Toward the outer or diamond ends of the coils there will be a force between the coil sides in the two layers tending to open out this angle; that is, the coil ends have a tendency to bow out to a rather semi-circular shape. The flux distribution around the semi-straight portion of the coil, between the inner elbow (X-X) and the diamond (outer) end, has much the same shape as if it were due to a

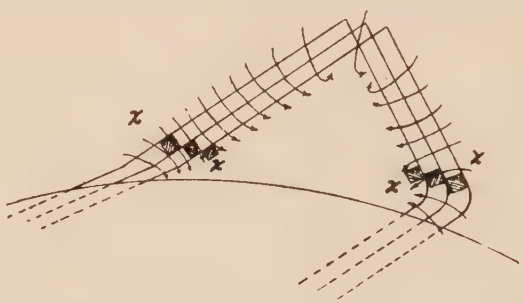


Fig. 12—Approximate Paths of the Flux Linking the Diamond Coil Armature End Winding

group of long straight conductors in air, far removed from other metallic parts.

Conclusions concerning the forces on the conductors within the conical surface of the end winding:

1. The forces on a single-phase short circuit tend to pull all the conductors together within one layer of the conical end winding.

2. The force is greatest on the inner coil sides of the group at the bend (or elbow) of the coil nearest the frame; from there it decreases toward the outer bend of the diamond coil.

3. In between these two bends in the coil the force may be 150 lb. per inch of conductor, or greater, on the assumption that the force may be computed as would be done for long straight conductors in air. The fact that the space within the phase group is limited indicates that the force should be greater than calculated; but if the correction for the coil shape is neglected, this is compensated for to a certain degree.

4. This force is sufficient to distort the winding unless bracing blocks, or the equivalent, are located between coils at quite frequent intervals.

5. Conductors which are two strands wide are very

much weaker than those which are one strand wide in the direction of this force. It is necessary that a manufacturer know the strength limitations of the coils and stay well within them. It should be noticed that while the resistance to shear between strands is very low, the copper is held on the ends so that tests on a short bar are not satisfactory. Undoubtedly testing coils to destruction on actual machines furnish the most reliable data on which to check calculations.

C. Forces on the Coil Extensions from the Frame

Tests on actual machines have shown that the straight parts of the coils extending from the slots over the retaining rings are almost as liable to failure as are the coil sides within either of the two layers of the conical end winding.

Fig. 18 indicates the probable sort of variation load against the edge of the coil.

Conclusions concerning the forces on the coil extensions from the frame:

1. There are fairly large tangential forces on the outer conductors of the phase group, similar to those within each layer of the conical end winding. However, these forces operate against the edges of the strands composing the coil sides. Bracing blocks are always inserted, and these can be made to give adequate support against such forces.

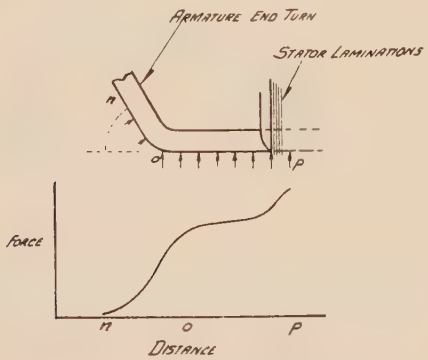


Fig. 18—Approximate Force against the Edge of the

2. The forces acting radially outward are of appreciable magnitude. These act against the coil in the direction in which the individual strands are the weakest; but there are many of them in the coil side. Tension and compression along these strands operate to prevent failure, the force falling off with distance from the slot toward the first bend or elbow of the coil, and very rapidly beyond the bend.

3. Experience indicates that this is a less likely place for failure to occur than within a layer of the conical surface of the end winding; but if the straight extension from the slots is long, special bracing should be supplied.

4. A matter deserving real consideration is the tendency to twist the conductor, due to the radial and tangential force exerted on the bend nearest the frame of the coil side at the inside of the phase group. Careful bracing on each side of this bend (section *X-X*, Fig. 12) must be used to so stiffen the mechanical resistance of the coil and supports that it will remove this possibility of failure.

D. Forces on the Phase Connecting Rings

Rectangular copper straps are bent into semi-circular arcs and used to connect the terminals of the machine to the ends of the various phase groups. These phase connecting rings are considerably closer to each other than to any heavy iron parts; they are located in a relatively weak part of the field of the armature end windings, and the radius of curvature of the rings is rather large. It therefore seems a reasonable approximation to assume that the forces on the phase connecting rings will be about the same as if they were straight conductors in air, well removed from other metallic parts.

The usual forms of bracing, blocking, and clamping are well known; on the whole, they are easy to apply; but in the machines in which the loading is large, special attention must be given to the ends of the phase connecting rings where they join the coil ends, as this is an inherently weak place in one-turn coils.

E. Forces on the Whole Phase Group in the Conical End Winding

A quantitative solution has not been worked out for estimating these forces; probably their directions are almost as important. The currents on the retaining ring (the real transient current and the imaginary current used to replace the saturation of the ring) will tend to produce an approximately outward force on the phase group. The coils are rather centrally located between the iron parts of the frame and end-bell, so that the effect of these latter parts should tend to cancel out.

It would be very desirable to have a definite but not too great force pressing the coils outward toward the coil supports which are mounted on the frame. Such an arrangement would eliminate any need of bolts through the winding to hold it back toward the frame. There are two ways to accomplish this. Laminated iron near the stator end plate to furnish a strong attraction would achieve this result, but commercially it is a rather impractical measure. A good conductor on the inner end-bell would carry eddy currents which would offer a force of repulsion to the armature winding and tend to force it back toward the frame. This is practical and expedient. An aluminum diffuser for a double-entrance fan will serve this purpose, but there is a possibility that such a thing might be very badly done; if the entire inner end-bell were made of aluminum or copper, probably under normal load conditions it would have high losses and possibly excessive heating. The reason would be that the path of the armature leakage flux would be too greatly restricted, and this damper would have to render a magnetomotive force almost equal to that of the armature. The smaller damper

will carry only a relatively small current and loss at normal load, but the tremendous increase in flux on short circuit will give sufficient current to produce a definite force in the desired direction.

In addition to the forces just discussed, where the resultant lies in a radial plane, there must be a tangential force acting on the phase group in the direction opposite to that of rotation. This torque will be due to the losses occurring in the end-bell, end plate, etc. It is as though these iron parts were the secondary, and the stator winding the primary, of a surface-wound induction motor, so that the burden of the torque falls on the armature conductors.

Summary

Fairly detailed conclusions have been given at the end of each section in the paper, so that only a brief summary will be made here.

Three methods of calculating the force exerted on current-carrying conductors have been demonstrated. The method involving the use of images can be used only when there is no appreciable degree of saturation. (The most common configurations to be imaged are summarized in Appendix C here omitted). The method involving the change of flux interlinkages is most useful where a reasonably simple mathematical expression can be obtained; but if the method involves the difference of two large values of interlinkages by the use of graphical field maps, it is not satisfactory. The method which uses the $\int H^2\, ds$ over any surface enclosing a conductor is the most generally applicable. It frequently involves the plotting of one quite difficult field map, but in such a case there is probably no way of avoiding this labor. (A simple proof is given in Appendix D of the complete paper for the basic principle of this last method for the calculation of the forces.)

The forces exerted on the embedded armature conductors during short circuit are computed, and the great influence of saturation is illustrated. It is shown that there are no electromagnetic forces tending to disrupt the coil sides by rending apart the strands; a graphical picture is given for the normal torque of a machine; the forces between coil sides in one layer of the conical end winding are computed; the forces on the straight coil extensions from the frame are approximated; the forces on the whole conical surface are discussed, and methods of causing the force to be definitely toward the frame pointed out, as is also the applicability of simple formula for approximating the forces on the phase connecting rings.

Acknowledgments

The writer greatly appreciates the assistance of Messrs. M. G. Leonard, A. M. Harrison, M. R. Lory, and R. D. Reed, in making the field maps; also the helpful discussions with Messrs. L. A. Kilgore and C. M. Laffoon.

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FIRE PREVENTION IN METAL MINES

A disagreeable odor, shot through ventilation lines at the rate of thousands of feet per minute, will be used to warn miners of fire in all metal mines complying with the provisions of the American Standard code for fire fighting in metal mines. The standard has been approved by the American Standards Association following its submittal by the National Fire Protection Association and the American Mining Congress, sponsors for the joint technical committee which has been working on the standard under American Standards Association auspices since early in 1925.

Provision is made in the standard for measures to be taken for the prevention of fires, fire fighting equipment, fire fighting personnel, and warnings of fires.

In addition to the use of a disagreeable odor as a warning signal, the standard also provides that in mines equipped with electric lights the engineers shall also flash all electric lights nine times in three series of three flashes each. Since trouble may develop in the electrical system, however, the odor signal is considered to be the more reliable warning.

Forecasting Seasonal Precipitation in California

Its Relation to Electric Power Production

BY A. F. GORTON*
Non-member

Synopsis.—*From an analysis of precipitation in significant districts of California, it is possible to deduce cycles or recurrences of from 2 to 3 years, from 5 to 6 years, and from 20 to 26 years, these being superimposed upon a longer or secular period of from 50 to 60 years. In this manner an estimate can be made of the rainfall to be expected over a relatively long period—as for the next 10 years; at the present moment, indications point towards greater precipitation and run-off in the period 1930-40 than in the preceding decade.*

Such estimates are of tremendous economic importance to agricultural interests and irrigation projects—such as the Hoover Dam, which involves storage of vast quantities of water for the creation of electric power and for supplying water to Los Angeles and other portions of southern California.

In order to forecast for a year or season at a time, it is necessary to make a statistical study of meteorological elements (including ocean temperatures) over a wide area during the preceding quarter or six months. Predictions of California rainfall based on the temperatures taken at inshore stations on the South Coast during the summer have been sufficiently successful to justify a continuation of the work. By using composite indexes, it is possible to increase the degree of correlation between computed and observed precipitation to a reasonably high figure.

Introduction

THE precipitation in California, as in other lands in the temperate zones, is produced in the main by "cyclones" or traveling storms (lows), borne by the prevailing westerly winds. For many years the Weather Bureau has mapped the paths of these storms, and it is a well-known fact that the storm-tracks are diverted towards the North in summer and towards the South in winter, in keeping with the changing declination of the sun. For this reason and because of the establishment of an area of high pressure off the California coast during July, August, and September, summers are dry on the West Coast, the length of the dry period varying with the latitude from two months at Portland to four months (at least) at San Diego.

Now, although the rainy season begins with September in Oregon and with October or November in the extreme South, the run-off of rivers and storage basins, which is the factor of immediate bearing on hydroelectric power production, exhibits a lag of, say, two months in Oregon and as much as four months in southern California; so that in the latter case, the run-off year coincides with the calendar year whereas the precipitation year coincides with the "fiscal" year extending from July 1st to June 30th. Because of this lag, it is possible to make a preliminary estimate of the seasonal run-off from the character of the precipitation during the fall months. Moreover, since depth of snow on the mountains adjacent to the storage basins has a significant bearing on the run-off as much as six months later, it is possible by means of snow surveys in January, February, and March, to revise earlier estimates of run-off with considerable precision.[1] Such methods, however, are of no avail in forecasting precipitation itself, which is the primary factor in water production.

Other elements enter into the power company's problem, most important of these being the growth of steam-powered plants and the necessity of balancing the production of, and capital investment in, the two types of equipment. Owing partly to a decrease in the price of fuel oil during the last few years, and partly due to economies inherent in the size and flexibility of operation of the producing units, cost of steam-electric power in some localities is now decidedly less than it was ten years ago, and perhaps less than the over-all cost of production by hydroelectric equipment of equivalent output. Evidently, then, to larger power companies, such as those serving southern California, foreknowledge of the price of oil in the near future may be as valuable as a reliable forecast of the coming season's weather anomalies.

Cycles and Trends in Rainfall

From a detailed study of the records for selected groups of stations scattered over the State, and the resulting plot of the seasonal precipitation (Fig. 1), it is possible to draw several conclusions: First, the curves show regional differences due to differences in latitude and topography. In the South, outstanding wet seasons come at intervals of eleven or six years, with dry periods in between. Further north, the variation seems to consist of a two-year alternation superimposed on a broader (secular) trend. This is better shown in the curves of accumulated departures from the normal (Fig. 2). The curve for Portland shows a long, gentle decline from a maximum at 1882, while at Sacramento the rise is not so abrupt, the maximum coming at approximately 1906. This behavior is not so apparent in the records for the Southern stations, where we have instead shorter trends of six, eleven, and twenty-two years. In fact, as to general appearance, the curves for Portland and Sacramento resemble more closely those of points much further east, such as Boston,

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1. "Forecasting Annual Run-off in the Klamath River Basin," John F. Partridge, *Electrical West*, 1928, Vol. 61, p. 321.

Presented at the Pacific Coast Convention of the A. I. E. E., Portland, Oregon, September 2-5, 1930. Printed complete herein.

Charleston, and the drainage basin of lakes Huron and Michigan.

In any study of rainfall data, the length of record covered by observations is of paramount importance. Unless a sufficient period of time has elapsed, it may be impossible to establish a reliable mean, or normal. Consideration of the older records, such as those of Charleston, Boston, Rome, and Padua, points to the existence of long swings or cycles covering 70 to 90 years or more. It is therefore important in considering rainfall records on the West Coast to compare the data for the station in question with that for Sacramento, San Francisco, or San Diego, (each of which now has an 80-year record), or even with an eastern station such as Boston or Charleston.

Owing to the essentially fortuitous nature of the seasonal (annual) figures at any one station or region, the straight plot of the precipitation, or even the curve of five-year means, is likely to show no regular periodicity. Similarly, a plot of the annual means of the "sun-spot" numbers shows nothing beyond the 11-year or elementary cycle. A more searching analysis is required to reveal the other cycles, and the first step is to "smooth" the curves by suppressing the shorter oscillations. However, the curve of accumulated de-

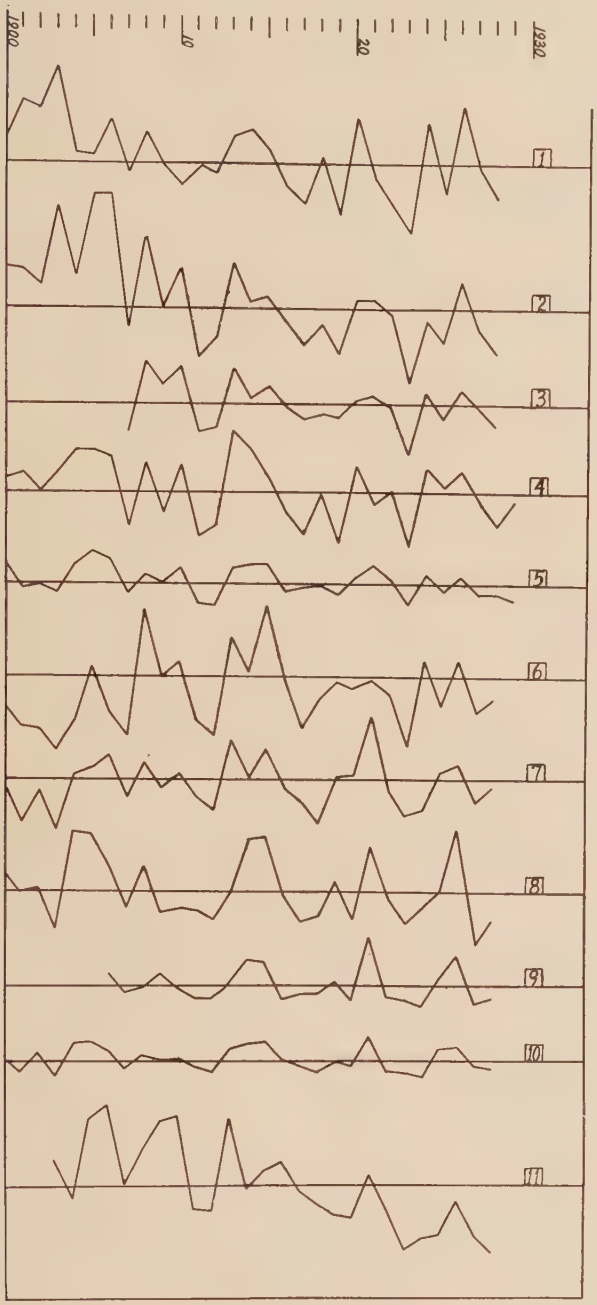


FIG. 1

Seasonal precipitation of selected districts in California, 1900-1930 (Season *begins* with year plotted) From top to bottom: (1) North Coast (Crescent City), (2) Tahoe, (3) Hetch-Hetchy, (4) Sacramento Valley, (5) San Joaquin Valley, (6) Springville-Kernville, (7) Lytle Creek (Los Angeles foot-hill district), (8) Cuyamaca, (9) Barrett Dam (10) South Coast (Los Angeles-San Diego), and (11) Owens River Run-off

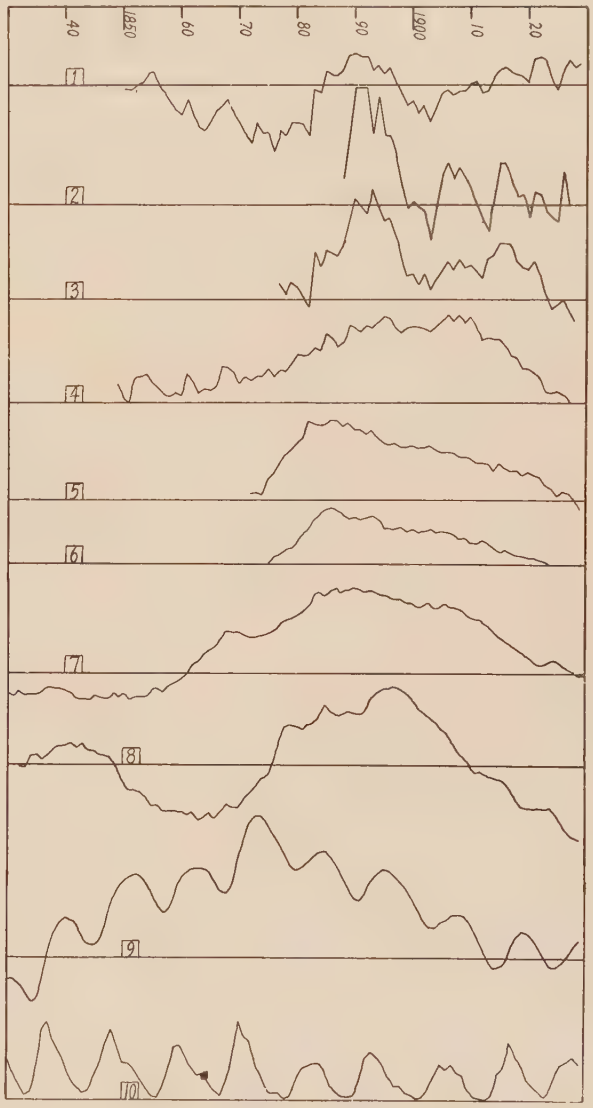


FIG. 2

Accumulated departures from the normal precipitation (mass curve) for stations scattered over the United States, showing similarity of trend of rainfall as well as the "secular" cycle. (Last two graphs show cycles in the sunspot or "Wolf" numbers.) From top to bottom: (1) San Diego, (2) Cuyamaca, (3) Los Angeles, (4) Sacramento, (5) Portland, (6) Drainage basin of Lakes Huron-Michigan, (7) Boston, (8) Charleston, (9) Sunspot numbers: mass plot, and (10) Sun-spots: straight plot of annual means

partures from the normal or "mass" curve, which is simply the first integral of the observed values, is only one way of "smoothing"—*i. e.*, suppressing the shorter variations and emphasizing the longer cycles. Other methods include lustrum (five-year) or decade means, "running" or "overlapping" five-year, ten-year, etc. means, and the more elaborate types of summational analyses, such as those of Clough and Streiff.[2] Application of these methods to California precipitation records reveals in the main the double-Wolf cycle of from five to six years, a longer one of from 22 to 26 years (Brückner cycle), and the two- to three-year or Clough cycle. The first is especially marked in records of southern California stations; it is moreover brought out by computing the frequency of occurrence of seasons with two or more consecutive months of decidedly abnormal rain—the San Diego record containing 13 such seasons in 72 years.

The recent work of Streiff points to interesting relations between characteristics of rainfall and streamflow in different parts of the globe, and between cycles brought out in these elements and those deducible from the sun-spot ("Wolf") numbers. Thus, rainfall records from both the East and West coasts of this country show the Brückner cycle, but displaced in phase by 180 deg. On the East Coast the "residual" curve of Wolf numbers is in phase with the rainfall; on the West Coast it is out of step with the rain. The Murray River in Australia shows the same (Brückner) cycle, there being a six-year lag between southern Australia and southern California. In this country, the Huron River, the Penobscot River, and others, all show the 11-year cycle in addition to shorter cycles, one of which Clough claims to have discovered in the sun-spot curve as well as in records of temperature and terrestrial magnetism.

In spite of the perplexity in the minds of many investigators regarding the reality of cycles in meteorological as well as solar phenomena, there is a two-fold reason for dwelling on the importance of establishing such cycles if it can be done in a sound, scientific fashion. In the first place, they will aid in placing meteorology on a *dynamic* basis, since thermal changes will be traced to variations in the solar output; (cycles in pressure have already been connected with solar changes). Since the ocean surface is much more important than the land as regards receipt of the energy from the sun, it is correspondingly more important as a source of back-radiation to the atmosphere. Consequently, the output of heat from the ocean surface (involving surface temperature, vertical temperature gradient, and circulation in the upper 50 meters at least) will be sought as an explanation of major changes in the seasonal weather of the continents. In the second place, it will be possible to make forecasts of the trend of precipitation over periods of 6, 11, and even 25 years. The value of such predictions to agricultural, economic, and financial interest—not to mention the large utility companies—could hardly be overestimated.

2. *Monthly Weather Review*, H. W. Clough, Vol. 56, 1928, p. 251; and A. Streiff, Vol. 54, 1926, p. 289.

Empirical Indexes of Seasonal Precipitation

A. Inshore Surface Temperatures: a Product of the Summer High and the Resultant Upwelling

While the climate of the Pacific Coast is influenced the whole year through by the thermal content of the nearby water, it is in summer that the effect is the most striking. Fog and cold water go hand in hand from Puget Sound to San Diego, and the best known case is of course the Bay of San Francisco. North of Cape Mendocino the water is normally cold due to the drift from higher latitudes. At and below Mendocino, however, owing to the southeastward trend of the coast line, upwelling of cold water from the depths of the ocean is the chief factor, and this depends on the direction and force of the winds, or, in other words, on the intensity and stability of the North Pacific high. Below Point Conception (Santa Barbara) the coast trends still further to the East, and in this region the upwelling is not so pronounced.

Surface temperatures at South Coast stations (such as La Jolla) will therefore exhibit departures from what would be the normal temperature for the latitude in question; and this effect is more marked in summer. High temperatures at La Jolla therefore may be taken as an expression of the comparative absence of upwelling and a weak development of the high, whereas low temperatures go with marked upwelling and a strong, rather fixed high. To what extent this is an indication of surface temperatures over a wider area of the ocean (particularly the triangle defined by Dutch Harbor on the North, San Francisco on the East, and Honolulu on the West) it is difficult to say. The records of various merchant ships show that at least within a few years, surface temperatures and barometer readings over the above area are in logical accord with upwelling as deduced from inshore temperatures.

Table I shows the record of surface temperatures

TABLE I

RELATION BETWEEN SURFACE TEMPERATURES AT LA JOLLA FOR THE PERIOD AUGUST 1ST—OCTOBER 15TH EACH SUMMER, AND THE RAINFALL ON THE SOUTH COAST THE FOLLOWING WINTER

Year	Temperature	Rain	Departure from 14-yr. mean	
			Temp.	Rain
1916	65.5	12.9	−1.8	0.6
1917	68.3	10.9	1.0	−1.4
1918	69.1	8.9	1.8	−3.4
1919	66.5	12.4	−0.8	0.1
1920	67.4	10.8	0.1	−1.5
1921	66.2	21.6	−1.1	9.3
1922	67.8	9.0	0.5	−3.3
1923	69.4	8.7	2.1	−3.6
1924	65.5	7.6	−1.8	−4.7
1925	66.9	16.8	−0.4	4.5
1926	67.4	17.8	0.1	5.5
1927	67.3	11.2	0.0	−1.1
1928	66.0	10.2	−1.3	−2.1
1929	69.1	13.0	1.8	0.7
Mean (14 yr.)	67.3	12.3		

taken at the Scripps Institution's pier, La Jolla, since the beginning of such observations in 1916. Each figure is the average of daily (8 a. m.) readings for the period August 1st to October 15th; or more precisely, from the 30th to the 41st week of the year, inclusive, (11 weeks). Departures from the (14-year) average are shown, together with similar data for rainfall in the South Coast district (six stations between Los Angeles and San Diego).

Opposition in the sign of the departures is noticeable particularly during the period 1916-1923 which on the whole was a dry period for the South Coast. The hypothesis on which the correlation rests is that a given abnormality of the surface water (high or low temperature in response to the influence of the summer high) will persist for another quarter or even six months. In brief, if the water be previously *cold*, stability of the high during the summer will tend to reinforce this state; correspondingly, if the water be previously warmer than normal, a weak development of the high will tend to preserve this kind of temperature departure.

These ideas are to some extent supported by a study of surface temperatures obtained in the North Pacific by Japanese merchant ships and published by the Imperial Marine Observatory at Kobe, Japan. These values appear in Table II. It is to be noted that in

TABLE II

DEPARTURES FROM THE NORMAL OF SURFACE TEMPERATURES IN THE GULF OF ALASKA ACCORDING TO THE KOBE REPORTS

Year	Winter Jan.–Mar.	Spring	Summer July–Sept.	Fall
1916	−	−	−	−
1917	+	+	+	+
1918	+	+	+	−
1919	−	−	−	+
1920	+	+	+	−
1921	(Data for 1921 not yet published)			
1922	+	+	+	+
1923	+	+	+	−
1924	+	+	−	−
1925	−	−	+	+
1926	+	+	+	+

1926 warm water prevailed for several seasons, whereas several years earlier, (1924), cold water was found. The inshore water was cold again in 1928, but records of Japanese ships for the Northern steamer track (Seattle-Yokohama) are not yet at hand, so that it can only be inferred that the water of the Gulf of Alaska as a whole was also subnormal. However, a recent report[3] from the Canadian Meteorological Service recorded not only that the water of the gulf was from one degree to three degrees below normal, but in addition, that the ocean west of the international meridian was correspondingly warm.

According to Sir Frederick Stupart,[4] the intensity of cyclonic development in the Dutch Harbor area during the winter depends on the degree of warming of the ocean adjacent to the colder land. In other words, the warmer the water, the more intense the storms; colder water should be linked with a weaker development of the cyclone. Moreover he believes that the character of the winters in western Canada can be traced to the thermal condition of the surface waters of the Alaskan Gulf. Thus 1925-26 was marked by warm water and a warm fall in South Alaska, with an exceptionally warm winter in the Canadian Northwest. In such years there is a tendency for the storms to move inland at high latitudes (above Puget Sound) and as a result, the pressure over western Canada is lower than normal. A further result is that the anti-cyclones push to the East of their regular track and affect Quebec and Labrador with a simultaneous strengthening of lows over the North Atlantic. Thus water temperatures in the Northeast Pacific may be linked with the weather over the North Atlantic during the fall and winter.

All of these ideas are more or less consistent with the Bjerknes hypothesis of the Polar Front[5] provided we assume that the presence of *cold* water in the Northeast Pacific will operate to draw the overlying cold (polar) air further south, and that *warm* water will induce the polar front to move further north. Applying this theory to California rainfall, we have a dynamic explanation for the manner in which the La Jolla index has been interpreted; that is, that warm water along the coast should be followed by a dry winter, and cold water during the summer should presage a wet season. However attractive this theory may seem, it must be admitted that observations sufficient to justify such a thermal interaction between the ocean and the atmosphere above it have never been made. Furthermore, although inspection of the available data on surface temperatures (Tables I and II) affords a strong presumption that the relation holds for a limited number of years, it is by no means certain that it is valid indefinitely.

B. Temperatures in Japan as Rainfall Indexes

The center of pressure over Siberia exerts a controlling influence on the waters adjacent to the Japanese archipelago, though more so in late winter and early fall than in other seasons of the year. Thus, temperatures at coastal points such as Nemuro in the north island and Tyosi on the main island, should react to variations in the thermal state of the nearby Pacific. The seasonal (quarterly) temperatures at Nemuro and Tokyo have been computed, Tokyo being chosen because it is sufficiently close to the coast to show a marine effect, and having, moreover, a much longer temperature

3. Patterson, John, *Bulletin* No. 68, National Research Council, Washington, 1929, pp. 76-88.

4. Proceedings, Third Pan-Pacific Science Congress, Tokyo, 1926, p. 1388.

5. The Polar Front is the border between the cold dry air of polar origin and the warm moist air of tropical origin. It is along this line that the cyclones (storms) of the temperate zone arise. See Bjerknes, V., "The Meteorology of the Temperate Zone and the General Atmospheric Circulation," *Monthly Weather Review*, 1921, Vol. 49, p. 1.

record; however, as shown by the table of correlation coefficients, temperatures in Japan do not on the whole furnish a reliable basis for predicting sequent weather in California. Over short periods (as in the last 15 years), fall temperatures in Tokyo (September-October and November-December) appear to be fairly reliable indexes of the trend of rainfall in the Hetch-Hetchy district. The largest correlation coefficient is 0.44 with a probable error of 0.12.

C. November Rains in Santa Barbara and Summer Rainfall in San Diego as Indexes of the Ensuing Season

A number of indexes tentatively put forward in recent years are based on the thought that a definite weather trend established early in the season will persist until the close of the season, or at least for a sufficient time to stamp the season as wet or dry, warm or cold. Thus, Blochman's indexes[6]—November rainfall at Santa Barabara and rain in San Diego during the summer—are typical of this class. The former index has a very good record, (over 90 per cent according to Blochman's researches), as has also the latter; but unfortunately both indexes have often been of negative significance in the last 12 years. The Santa Barbara index has definitely failed in the years 1918-22-27-28. Table III summarizes the

TABLE III

CORRELATION COEFFICIENTS OF VARIOUS INDEXES

With precipitation in northern and southern California

Index	Precipitation district	Period	Correlation coefficient
Hueneme summer temp.	South Coast	1916–29	0.79
Oceanside summer temp.	South Coast	1921–26	0.61
Pacific Grove summer temp.	South Coast	1919–29	0.34
Tokyo Sept.-Oct. temp.	Hetch-Hetchy	1907–28	−0.44
Tokyo Nov.-Dec. temp.	Hetch-Hetchy	1907–28	−0.42
Tokyo Mar.-May temp.	South Coast	1900–28	−0.37
Tokyo Mar.-May temp.	Hetch-Hetchy	1907–28	−0.33
Santa Barbara Nov. temp.	Crescent City	1900–27	0.36
San Diego Sept.-Oct. rain	Crescent City	1900–27	−0.40
Composite index of Hueneme and La Jolla summer temp.	South Coast	1919–29	−0.84
La Jolla April-May temp.	South Coast	1916–30	0.47
La Jolla July-Sept. temp.	Hetch-Hetchy	1916–30	−0.57
La Jolla July-Sept. temp.	Huntington Lake Inflow	1916–29	−0.61
La Jolla Upwelling period	Huntington Lake Inflow	1916–29	−0.47
*La Jolla Upwelling period	Huntington Lake rain	1916–30	−0.68
*Tokyo Sept.-Oct. temp.	Hetch-Hetchy	1916–30	−0.65
*Tokyo Nov.-Dec. temp.	Hetch-Hetchy	1916–30	−0.43

*The last three correlations were made by successive differences.

results of our computations as to the behavior of various indexes, both marine and continental, compared with the amount of precipitation in the significant districts of northern and southern California. One must remember that the mere correlation coefficient does not tell the whole story. A high numerical value does not necessarily mean a close relationship when the observational basis is scanty; on the other hand when the observations cover a long period, a moderate value of the coefficient may be quite significant and the probability of error low. In general it may be said that the coefficient is a mathematical device for expressing the degree of correspondence between two curves. In terms of departures from the mean, a high positive coefficient implies that the respective departures of the two factors are proportional and of the same sign. When the coefficient has a high negative value, a large positive departure of one factor matches a large negative departure of the other, and vice versa. In other words, one curve is the optical reflection of the other curve.

It should be noted that by combining two or more indexes by the method of Least Squares, and comparing the composite index with the rainfall, it is possible to obtain even higher coefficients than by use of a single index. This may be done also by the method of Partial Coefficients, illustrated by the recent work of the British meteorologists.[7] In either case there is often a decided lack of fit between the computed and observed rainfall in the last year, or even in the last several years of the record. Due to occasional failures, many people lose faith in such forecasts. These, however, are inherent results of the mathematics employed and do not mean that the correlation may not have a high value over a longer period.

Summary

Analysis of the precipitation of the more important districts of California reveals variations ascribable to differences in topography and to variations in the paths of the seasonal storms. Cycles or recurrences of 2-3 years, 5-6 years, and 22-26 years, are apparent from the graphs for both northern and southern California, these being superimposed upon a longer or secular period of approximately 50 to 60 years. Some sort of connection with solar phenomena is indicated possibly by the fact that the sun-spot maxima of 1870, 1893, and 1917 mark the beginnings of dry periods of as much as six years' duration.

Forecasts of the wetness or dryness of extended periods of, say, from six to eleven years, would seem to be almost as important to certain interests as predictions of the seasonal precipitation. The problem of supplying water and power to the rapidly growing cities of southern California, and the irrigation demands of the agricultural districts, have reached a stage where it is necessary to plan for the probable consumption of 10 to 20 years ahead. The Hoover Dam Project has served to emphasize this point, as everyone realizes that in undertaking an engineering work of such huge proportions, it is vital to estimate with some exactness the average run-off of the Colorado River (and consequently the average rainfall over the drainage basin), as otherwise the height of the dam would prove to be either too great or too little.

6. Blochman, L. E., *Monthly Weather Review*, 1925, Vol. 53, p. 489.

7. Bliss, E. W., *Quarterly Jl. Roy. Meteor. Soc.*, 1930, Vol. 56, p. 67.

Whether such an estimate can be made intelligently at the present time is open to dispute, but general opinion among hydraulic engineers is in agreement with conclusions based on graphs shown above; *i. e.*, that the period 1929-1940 will be wetter than the preceding decade.

As to forecasting indexes applicable to the seasonal precipitation, it would seem that the ocean temperatures taken during the summer at inshore points between Cape Mendocino and San Diego furnish on the whole a more reliable basis than observations of water temperatures or weather elements at much more distant points. The index with the highest coefficient at present is that based on a combination of surface temperatures at the inshore stations, Hueneme and La Jolla, and the ratio of probable error to the coefficient (0.06 to 0.84) is small enough to justify considerable faith in the reliability of the index. The most obvious criticism is that it rests upon such a limited observational basis. However, if our investigations reveal one or more additional factors related to subsequent seasonal rainfall, and all are combined as was done in developing the Indian[8] forecasting systems, the chances are that the resultant correlation coefficient will be greater than that for the present index.

8. Walker, Sir Gilbert, "World Weather," *Monthly Weather Review*, Vol. 56, 1928, p. 167.

Abridgment of

Damper Windings for Hydroelectric Generators

BY C. F. WAGNER*

Member, A. I. E. E.

Synopsis.—*The severity of unsymmetrical system faults is affected by the negative sequence impedance of the connected machines. These impedances in turn depend largely upon the character of damper windings. The paper discusses the effect of amortisseur or damper windings upon both the real and reactive components of the negative sequence impedance. Machines without damper windings possess the highest negative sequence reactance and from this point of view, are the more desirable; but machines with high-resistance damper windings possess the highest negative sequence resistance. Calculations show that combining the effect of resistance and reactance, the high-resistance damper is the more desirable.*

In the event of system oscillations, low-resistance copper damper windings produce the greatest damping of the mechanical movement; however, this effect is unimportant during and following a system fault except in the rather rare case in which the system is so constituted that pull-out takes place as a result of compound oscillations following a disturbance.

Consideration is given also to a special type of double-deck damper winding.

* * * * *

Introduction

AMORTISSEUR or damper windings have been installed in hydroelectric generators in the past only when particular requirements such as increased starting torque for automatic operation demanded it. In general, hydroelectric generators in manually-controlled power stations were not equipped with damper windings. The recent emphasis placed upon stability problems and power limits has raised the question as to whether or not, from stability considerations alone, some form of damper winding was desirable. It is the purpose of the present article to discuss some of the factors affecting the choice of damper windings for hydroelectric generators.

I. Negative Sequence Impedance

It has been shown by Evans and Wagner[1] that through the application of the "method of symmetrical components," any unbalanced fault in a symmetrical† power system can be represented by means of a symmetrical set of impedances connected in shunt at the point of fault, thus converting the unbalanced fault to a symmetrical impedance load, which is more amenable to solution. For a line-to-line fault the shunt impedances are all negative sequence impedances, but for other types of faults the shunt impedances are a combination of negative and zero sequence impedances. It follows therefore that any change in the negative sequence impedance of a generator will alter the severity of the fault and affect the stability limit.

What is the nature of this negative sequence impedance? The method of symmetrical components involves the resolution of three unsymmetrical currents or voltages into (1) a positive sequence set of currents or voltages whose maximum occur in the order *a, b, c*; (2) a negative sequence set of symmetrical currents or voltages whose maximums occur in the order *a, c, b*; and (3) the zero sequence currents or voltages which are equal and in phase in the three phases. Now while all of these vectors rotate in the same direction, when applied to a phase-wound machine, the positive sequence produces a field rotating synchronously in the same direction as the rotor, and the negative sequence

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1. For references see Bibliography, complete paper.

†Symmetrical is used here to describe a system that has the same characteristics and constants viewed from any phase.

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a field rotating synchronously in the opposite direction. The negative sequence impedance of a machine is that offered to the flow of negative sequence current; that is, it is the negative sequence voltage across the machine when one unit of negative sequence currents flows through the machine. This impedance may be resolved into a real component called the negative sequence resistance and a reactive component called the negative sequence reactance.

Negative Sequence Reactance

The field winding constitutes a short-circuited winding for the rotating field. In a machine without damper windings the absence of a winding in the quadrature axis permits the rotating flux to build up in the the quadrature axis. For this reason machines without damper windings possess a relatively large negative sequence reactance. Damper windings of the ordinary type introduce short-circuited windings in both the direct and quadrature axis, so that the negative sequence reactance is reduced a very considerable amount.

Negative Sequence Resistance

For a machine without dampers the only source of power loss when negative sequence voltage is applied is in the armature and field resistances, eddy currents, and iron loss. The copper loss in the armature and field is very small, as is also the iron and eddy loss in the armature but the iron and eddy loss in the rotor may reach quite high values. Copper dampers provide a lower impedance path in the eddy currents, and hinder the penetration of flux into the pole structure. The relatively low resistance of this path results in a smaller negative sequence resistance. For higher resistance dampers the negative sequence resistance increases to a point beyond which the larger resistance diminishes the current in the rotor circuit sufficiently to decrease the loss. The following test results of negative sequence impedance illustrate the effect of the damper material for a 5000-kv-a. condenser.

Material	Negative sequence impedance in per unit of machine rating
Copper	$0.026 + j\,0.195$
Brass	$0.045 + j\,0.195$
High resistance	$0.12 + j\,0.20$
No dampers (but with damper slots)	$0.045 + j\,0.75$

The effect of these impedances upon the power limits naturally depend upon the particular kind of fault, the location and the duration of the fault under consideration. The results of calculations made for a characteristic system for different kinds of faults as a function of the duration are shown in Fig. 3. These curves take into consideration, only the effect of the alteration of the negative sequence, all other properties remaining the same.

Alteration in Generator Torque During and Following a System Fault Due to Currents in the Damper Windings

At times of any symmetrical change in machine conditions such as short circuits or change in operating angle, transients are set up in both the field and the armature. For all practical purposes these transients may be reduced to (1) a unidirectional component in the field with its associated fundamental frequency transient in the armature, and (2) a fundamental frequency transient in the field and a unidirectional and double frequency transient in the armature. It can be shown that while the latter components are important in determining the maximum mechanical stress between turns or the maximum impulsive torque exerted on the shaft, for three-phase short circuits on the terminals of the machine, because of their rapid decrement for other types of faults, they are unimportant in their net effect upon the angular oscillations following a system disturbance. Therefore the latter components will be neglected, consideration being given to the former. As previously stated, unbalanced faults can be reduced to equivalent symmetrical circuits so that the analysis pertaining to transients in symmetrical circuits may be applied to the resultant positive sequence network. For machines without damper windings, the unidirectional transients in the rotor structure occur only in the field winding. The presence of the damper winding introduces additional paths for current flowing in both the direct and quadrature axis of the rotor. To evaluate the effect of these currents upon stability limits a line-to-line fault was applied for 0.2 sec. to the high-voltage bus at the generating end of the 60-cycle system shown schematically in Fig. 4 with three power—angle diagrams representing the circuit condition before, during, and following the faulty condition. The effect of the currents in the damper windings upon the power—angle diagram are shown by the shaded areas. During the fault condition as represented by the lower curve, the shaded area increases the severity of the fault and is therefore detrimental, whereas following the switching operation, the shaded area is advantageous. The net effect is to increase the power limit for this particular case about one-half of one per cent.

In this calculation the use of copper dampers was assumed. With the same construction using brass dampers, both of these areas would be considerably decreased and the effect upon the stability limit would be negligibly small. The same considerations also apply to higher resistance dampers.

Hunting

The phenomena associated with hunting involves the time lag of the reactions within the machine behind the actuating forces. If a sinusoidal oscillation be superimposed about the angle at which the machine

is operating, the operating locus, instead of moving along the same locus with increasing angles as with decreasing angles, forms an elliptical loop as shown in Fig. 6. The area of this loop represents the energy absorbed during each oscillation or the energy which must be supplied to sustain the oscillation. If this energy is not supplied, the oscillation will decrease in amplitude, as shown by the inclined spiral in Fig. 6.

perature on the rotor structure; however, if the fault is relieved within five seconds these temperatures are not dangerous. The normal current unbalances met in practise will not produce much increase in loss.

The presence of damper windings increases the breaker duty from the standpoint of increased current, but from a standpoint of lower recovery voltage reduces the duty.

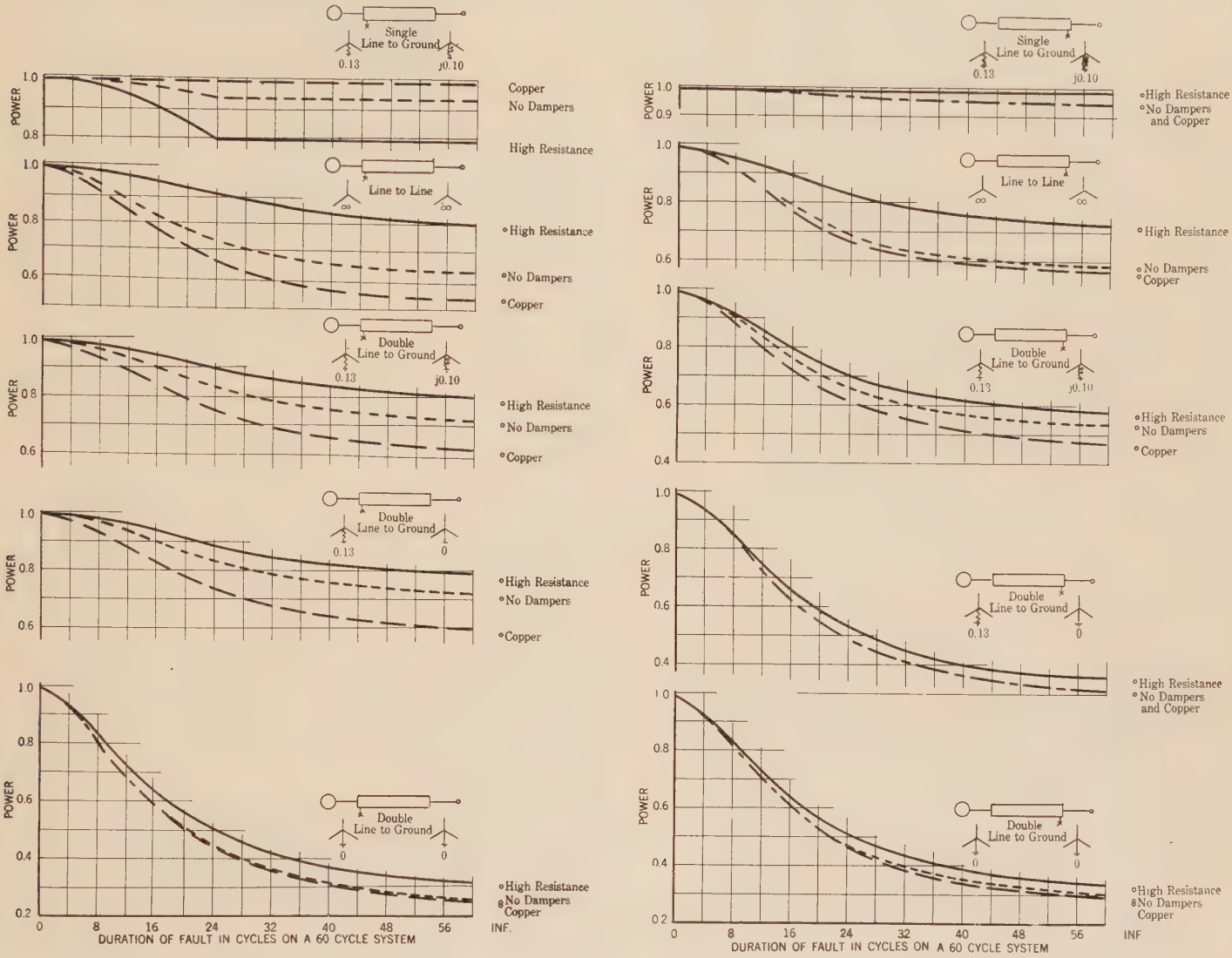


FIG. 3—STABILITY LIMITS WITH DIFFERENT KINDS OF FAULTS AND DAMPER WINDINGS AS A FUNCTION OF THE DURATION OF THE FAULT

A. Fault on high-voltage side of sending-end transformer

B. Fault on high-voltage side of receiving-end transformer

This figure was drawn for representative values using a copper damper, and shows that the damper is quite effective in eliminating tendencies toward hunting and in producing damping of oscillations. Brass and high-resistance dampers possess this characteristic to a much smaller degree.

MISCELLANEOUS CONSIDERATIONS

The increased energy absorbed during fault conditions by dampers of high resistance raises the temperature on the rotor structure; however, if the fault is relieved within five seconds these temperatures are not dangerous. The normal current unbalances met in practise will not produce much increase in loss.

The presence of damper windings increases the breaker duty from the standpoint of increased current, but from a standpoint of lower recovery voltage reduces the duty.

The question also arises as to the effect of the damper winding on quick-response excitation systems. The amount of copper associated with the damper winding is always small in comparison with that associated with the main winding, and for that reason is relatively unimportant in connection with quick response.

DOUBLE-DECK DAMPER WINDINGS

In an attempt to secure the advantages of increased stability limit obtainable by means of high-resistance

dampers, and the damping of oscillations following a system disturbance, obtainable by means of copper dampers, a double-deck damper was constructed. This consists essentially of two distinct sets of windings; the lower one of copper completely buried in the rotor iron, and the upper one of high-resistance material with an air-gap inserted in its magnetic circuit. For the negative sequence reactance the double-system frequency currents in the rotor impart high reactance to the buried copper damper and divert the current to the high-resistance material, thus producing high negative sequence loss. The low value of natural frequency of oscillation of the system is still sufficiently low so that the current division between the high- and low-resistance dampers is determined by their resistances, which result in most of the current flowing through the copper dampers and producing high damping.

Conclusions

The choice of the most appropriate damper winding is dependent upon the emphasis to be placed upon the different characteristics. The desirable property of rapid damping associated with copper dampers should be of value only in special cases in which there is danger of compound oscillations of such character that pull-out occurs on the second or third oscillation. Only rarely has such a case come to the attention of the author and his associates. When pull-out does take place, it usually occurs on the first swing. High-

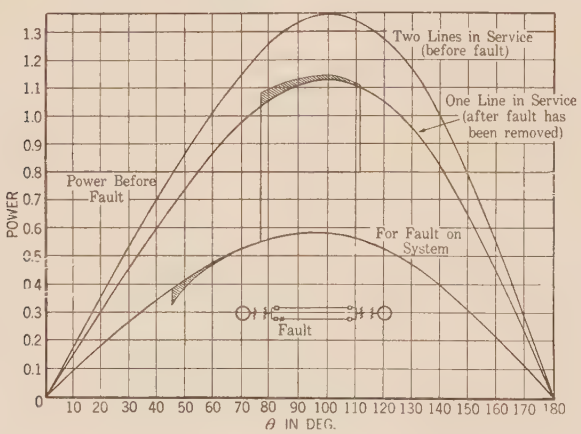


Fig. 4—Increment in Power During and Following a Fault Due to Induced Currents in the Damper Bars for a Typical Machine Assuming Copper Dampers

Line reactance $= j\,0.3$ per line
Transformer reactance $= j\,0.1$
$x_d = 1.0 \quad x_q = 0.6$
$x_{d'} = 0.4 \quad x_{q''} = 0.35$
$x_{d''} = 0.3$
$T_{do} = 5.0 \quad T_{do''} = 0.04 \quad T_{qo''} = 0.12$
$e_{d'} = 1.0 \quad E = 1.0$
Stored energy per kv-a. = 2.6 kw-sec.

resistance dampers should be of value, regardless of the nature of the oscillations, and from this viewpoint are more desirable. Double-deck or similar dampers are somewhat of a compromise, conferring on the machine some damping characteristics (but not as much as though both windings were of copper) and at the same time increasing the stability limit because of the increase in power absorbed by the damper (but not as much as for a higher resistivity material, occupying the same space and using the same temperature; a loss must result either in stability limit or in tempera-

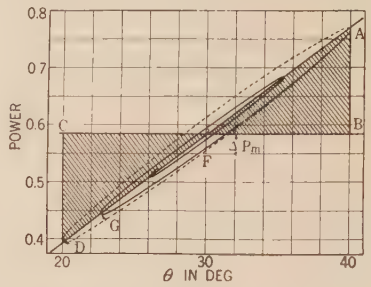


Fig. 6—Illustrating Maximum Deviation of Power from Mean for Sinusoidal Oscillations and Decrement of Free Oscillations Due to Energy Absorbed

ture tolerance). These conclusions are premised upon a given pole shoe. Of course, more effective dampers can always be installed if more space is made available, by increasing the distance from field coil to the outer edge of the pole shoe. This necessarily increases the diameter of machine and results in a greater increase in cost than is justifiable by the improvement in stability.

COLORADO RIVER PROJECT

The Supreme Court of the United States, on October 13th gave permission to the State of Arizona to begin an original action in that tribunal contesting the right of the Department of the Interior to proceed with the construction of the Hoover Dam, and directed that process be returnable on January 5, 1931. On the same day, Secretary Wilbur announced that the Comptroller-General had denied the request of Arizona that he withhold approval of the use of funds for the construction of the dam.

In announcing the action of the Comptroller-General, Secretary Wilbur declared that construction of the dam will proceed with all possible expedition.

President Hoover, at a press conference on October 14th, said:

> The letting of contracts for the construction of the Boulder Dam project will proceed as rapidly as possible. The determination of the points of law raised by Arizona will be expedited as far as the federal government is concerned. In the meantime, I am in hopes that the states may get together and compose their differences. They are not so far apart as to make a settlement infeasible.

It was announced by Secretary of the Interior Wilbur on October 15, that a contract for all the electrical power the government will use in constructing the Hoover Dam has been let to the Southern Sierras Power Company of Riverside, California. Based on the estimated power requirements for construction work, lighting the city to be built for the working forces, pumping water and all other needs, the total cost to the government will be about $1,730,000.—*N. E. L. A. Bulletin.*

Abridgment of

Long Telephone Lines in Canada

BY J. L. CLARKE[1]

Associate, A. I. E. E.

Synopsis.—*This paper describes the development of the long distance telephone service in Canada, historically, from its inception and the installation of the nucleus of 360 mi., up to and through the present status and lines listed in Table I, to the proposed development represented by Table II, the result of a careful study of calls per day to be expected by 1932. This effort is to provide for traffic requirements in a manner most suitable from a transmission point of view, and to accomplish it with a minimum amount of switching. Much of the engineering work for this is already actively under way and certain work of construction actually commenced. A survey of existing routes and the matter of transmission maintenance discussed.*

Historical

FROM Montreal to Toronto 35 years ago, a telephone line was constructed over a distance of 360 mi. At that time technical limitations were such that about 400 mi. was the maximum distance over which good telephone service could be given; hence the above mentioned circuit was then considered a very long telephone line.

Since that time the telephone horizon has expanded to a very marked degree, and with this expansion has come the change of ideas as to what constitutes a long telephone circuit.

For many years, telephone development in the Dominion of Canada was in character, local; in small areas isolated from each other service was started and gradually spread out and became linked with adjacent areas. Because of the great expanse of country and the sparseness of population, economic difficulties exercised a severe restraint on the construction of the longer links required to bridge the gaps between various settled areas of the country.

Telephone connections between the Bell System in the United States and certain of these areas were early established and provided a means of communication between various sections of Canada at a time when direct circuits through the Dominion were not economically feasible.

This arrangement possessed marked advantages; first, it provided telephone service between different communities in Canada which would otherwise have been isolated; second, it permitted this traffic to grow until it finally reached a point where it became possible to justify the building of direct links through Canada.

By the year 1927 the progressive linking together of the various areas throughout which telephone service was being given had reduced the number of separated territories to four: the maritime region including the provinces of Nova Scotia, New Brunswick, and Prince Edward Island; the Central Region including the settled portions of the provinces of Ontario and Quebec; the Western Region including a large part of the provinces of Manitoba, Saskatchewan and Alberta; and the Pacific Region including the Southwestern part of the Province of British Columbia.

Fig. 1 shows the regions in the Dominion of Canada where appreciable telephone development exists. In the gaps between the shaded regions, the nature of the country was unfavorable to telephone line construction, the road connections incomplete, and the settlements few and far between.

The Central and Western regions are separated by nearly a thousand miles of very rough and almost uninhabited country, the terrain of which was very difficult to traverse, with a continuous succession of rocky hills and ridges exhibiting no regularity



Fig. 1—Map showing Telephone Development in Dominion of Canada

of form or direction. Interspersed among these hills are small lakes[2] and patches of muskeg.

Between the maritime region and the central region there was a long stretch of rough and sparsely populated country, not entirely without roads and certainly presenting less of difficulties than either of the other two. In 1928 a pole line was constructed in this section and telephone conductors were erected to provide circuits from Quebec and Montreal to Saint John, N. B.

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Presented at the Summer Convention of the A. I. E. E., Toronto, Ontario, Canada, June 23-27, 1930. Complete copy upon request.

2. In 1929 certain sections of road in British Columbia, necessary to bridge various gaps between existing roads, were completed and although the route is somewhat circuitous, it is now possible to travel by automobile from Vancouver to Calgary. As yet there is no highway extending through the section of country lying north of Lake Superior.

This left two unbridged gaps, but completing these missing links by means of the erection of pole lines crossing these sections involved formidable problems both in construction and subsequent maintenance of lines.

There existed an alternative method of carrying telephone circuits across these gaps; the main lines of both the Canadian Pacific Railway Company and the Canadian National Railways crossed these sections, and the telegraph systems of these railways possessed pole lines along the railroad right-of-way. The possibility of making use of one or the other of these pole lines for telephone circuits was carefully investigated and the plan found practicable.

Negotiations were opened with the railway companies and an arrangement made with the Canadian Pacific Railway Company for the use of facilities by which telephone communication could be established. The necessary telephone repeaters were obtained and placed at suitable locations, and in August 1928 a telephone line was put into operation between Sudbury and Winnipeg; a few months later connections were established by similar means between Vancouver and Calgary.

There was another important factor which had to be taken into consideration—the ownership of facilities. In the United States the telephone system of the American Telephone and Telegraph Company and its associated companies extends from coast to coast, whereas in Canada the telephone service is provided by a number of independent organizations. Prolonged negotiations were necessary in order to arrive at an understanding in this matter, and evolve a plan mutually satisfactory and one in accordance with which steps could be taken to inaugurate a system of long-haul telephone circuits suitable for universal service between all sections of the Dominion; also to coordinate the construction, maintenance, and operating practises of the various telephone systems so as to permit the satisfactory functioning of these interregional circuits.

Existing Circuits

At the present time long circuits as shown in Table I are in operation; these lines are all two-wire voice-frequency circuits, some of them located on the same pole line as long distance commercial telegraph circuits—in one case, for approximately 1000 mi. This caused the telephone circuits to be exposed to severe inductive effects from the telegraph currents and special means had to be adopted to avoid undue interference resulting in excessive noise in the telephone circuits.

TABLE I

Circuit	Approximate length of circuit	No. of through line repeaters
Montreal-St. John	620 mi.	4
Montreal-Halifax	890 mi.	6
Toronto-Winnipeg	1285 mi.	9
Calgary-Vancouver	625 mi.	4
Sudbury-Winnipeg	973 mi.	5

These circuits function satisfactorily in providing telephone links between adjacent regions, but the two-wire voice-frequency type of telephone circuit has certain inherent limitations which become apparent when attempts are made to make use of this type of facility for establishing very long telephone connections.

These limitations are such that the existing voice-frequency open-wire circuits are not entirely satisfactory for every possible connection between alternate regions. In order to provide a suitable grade of transmission between all points in the various regions in Canada, and particularly for those cases where very long telephone connections will be involved, circuits with high inherent transmission stability and good over-all transmission qualities will be required. As it is not possible to provide direct circuits between all the regions, the circuits provided must be suitable for interconnection by means of switches in order to establish built-up connections. The transmission requirements for the design of these very long telephone circuits are materially more severe than those of much shorter lengths and, as discussed below, in many cases it has been found necessary to use carrier telephone systems superimposed on open-wire lines having special wire configurations and with transmission regulation arrangements.

Proposed Long Circuits

The introduction of the circuits shown in Table I has resulted in a rapid increase in the traffic between adjacent regions, and additional facilities are now required to meet the demand for service. The longer-haul traffic has also increased to a point where it is now sufficient to warrant the construction of longer direct circuits between various points in Canada.

The results of a traffic study covering the number of calls per day expected in 1932 between certain of the more important points are, as follows:

Toronto-Vancouver	27
Winnipeg-Calgary	156
Winnipeg-Vancouver	54
Montreal-Winnipeg	107
Toronto-St. John	36
Montreal-Halifax	72

In order to provide for these traffic requirements in a manner most suitable from a transmission point of view and with a minimum amount of switching, the network of facilities as shown in Table II has been proposed. The engineering work involved in the design and construction of these facilities is now actively under way, and in certain cases the actual construction work has already commenced.

At some later date it is proposed to construct a Toronto-Vancouver circuit. This circuit will be obtained from carrier type facilities and will be 3100 mi. in length.

The circuit layout as proposed for 1932 will provide telephone connections between any two of the main toll centers shown in Fig. 2 with not more than two

switches. The cities shown in Fig. 2 are the principal long-distance outlets for each province.

Engineering studies of the most economical methods of providing the required plant layout were undertaken

TABLE II

Circuit	To be completed	Length of circuit	Type
Toronto-Winnipeg.....	1930	1285 mi.	Carrier telephone
Montreal-Winnipeg.....	1930	1600 mi.	Carrier telephone
Montreal-Winnipeg.....	1931	1600 mi.	Carrier telephone
Winnipeg-Calgary.....	1931	974 mi.	Carrier telephone
Winnipeg-Calgary.....	1931	974 mi.	Voice - frequency telephone
Winnipeg-Vancouver....	1931	1820 mi.	Carrier telephone
Calgary-Vancouver.....	1931	850 mi.	Carrier telephone
Calgary-Vancouver.....	1931	850 mi.	Voice - frequency telephone

in order to establish plans which would be most practicable for the immediate future and would also anticipate the probable requirements for some time to come.

As it appeared that ultimately it would be desirable to develop the trans-Canada system on a carrier basis

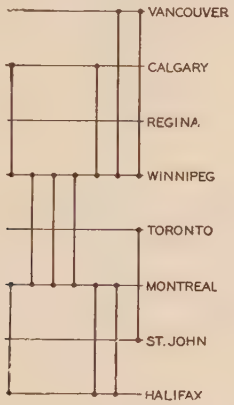


FIG. 2—PROPOSED CIRCUITS IN 1932
(This program does not include circuits terminating in adjacent provinces)

(at least until such time as toll cable would be warranted) and that a maximum number of carrier systems would therefore be required, it was found economical to construct the proposed facilities on the new non-phantomed arrangement. This method involves the abandonment of the phantoms and the spacing of the wires of each pair only eight inches apart. Material benefits in the form of cross-talk and noise reductions are possible with this type of construction. The use of special, improved insulators was also found to be of advantage, in that they reduce the variations in attenuation under different weather conditions and would thus tend to improve materially the over-all stability of the circuits. This factor is of special importance at carrier frequencies where with the normal types of toll line insulation, the variation in attenuation under different weather conditions may be appreciable. The use of the non-phantomed layout of course also indicated the desirability of special transposition arrangements which would provide for the maximum application of carrier facilities.

SURVEY OF EXISTING ROUTES

In order to determine the most advantageous routes for these circuits, a comprehensive survey of existing facilities was undertaken. It was necessary to ascertain the most suitable points in each province to be connected to this network and then, by means of the data supplied by the survey, to determine the most advantageous routes between these points.

The principal factors receiving consideration in this connection were the physical conditions of existing pole lines, the directness of the route between particular points, the possibility of obtaining suitable locations of repeater points, and the expense of necessary changes to the pole line and the circuits existing on the pole line in order to render it suitable for long-haul circuits. The determination of the condition of the various sections of the existing open-wire leads is made normally on the basis of a pole line inspection. The results of this inspection would indicate those portions of the route which would be suitable without an appreciable amount of reconditioning, and would also determine those sections which might require strengthening or replacement due to poor condition, lack of uniformity, or susceptibility to interference from power exposures, fire hazards, or other external influences. A valuable factor in this survey work would be the possibility of scheduling the various construction items so that the work could be properly coordinated with the provision of the facilities. With the results of this survey and the knowledge of the wire loads to be carried, requirements for the size and character of the poles for the different sections could be determined, having in mind the relative exposure to weather conditions, and the factors of safety desired.

In order to obtain adequate limitation of cross-talk between carrier channels it is essential to maintain the spacing between successive transposition poles within close limits. This requires an accurate survey of the pole line in order to determine the precise location of each pole.

Another important engineering item is the location of the various repeater points for the carrier-frequency, voice-frequency, and d-c. telegraph facilities. These points are determined by a study of certain transmission features of the circuits, the principal effects receiving consideration being the attenuation, noise, cross-talk and echoes.

Other factors, such as the desirability of having repeater points at locations which would be readily accessible, where adequate personnel could be obtained and where the facilities terminated or branched off to other routes, were considered.

The matter of alternative routes in case of failure of a particular link was also the subject of considerable study. In some sections, only one Canadian route was available; this was the case in the section between North Bay and Winnipeg. In all cases there was a possibility of routing the calls via United States' points during temporary failures due to storm conditions.

The map in Fig. 3 shows the route chosen and the proposed alternative routes.

Transmission Maintenance

Due to the greater amounts of apparatus and plant facilities involved, and the importance of the greater inherent transmission variations of very long telephone circuits, the transmission maintenance of suitable over-all transmission standards requires relatively more attention than with shorter transmission systems. In order to provide adequately for these features and to assure the highest degree of efficiency and cooperation in the operation and supervision of these facilities, an extensive investigation was made of the various factors involved; also suitable procedures and arrangements were planned accordingly. This investigation included among other points consideration of the following:

1. The formulation and adoption of uniform transmission maintenance practises.
2. The allocation of responsibility for sectionalized testing and maintenance work and for over-all circuit control.
3. The organization and training of plant personnel.



Fig. 3—Proposed Route of Trans-Canada Toll System

Showing alternate routes

4. The provision of adequate testing apparatus at all points.
5. The establishment of suitable plant communication systems for maintenance purposes.

Further consideration of the more important points in the establishment of suitable transmission maintenance arrangements are summarized in the following paragraphs:

Experience has shown the necessity of setting up rigid practises for the maintenance of transmission systems of the type proposed in this paper, and the importance of uniform treatment for the respective facilities throughout their entire length. This is of greater importance where the plant and personnel include those of different independent telephone organizations. Plans have been made therefore for the preparation of uniform practises which may be applied to all the regions and the establishment of suitable supervisory means for coordinating the over-all maintenance results. These practises provide for the suitable testing and maintenance of each individual part of the circuit, the individual apparatus units, and the over-all circuits and systems.

The magnitude of the project and the lengths of the various circuits involved required a careful consideration of the most desirable methods of allocating the responsibilities of the testing and maintenance work so that a minimum of lost circuit time and of unsatisfactory transmission conditions would be incurred. This resulted in the division of the facilities into sectionalized units with one important office in each section designated as the control point. The personnel at this office would be responsible for, and control, the maintenance work necessary on the toll plant within the limits of its section length. An arrangement of this nature should in general simplify the maintenance problem and furthermore, it would have the advantage of concentrating the supervisory personnel in a limited number of points. In addition, in order to supervise properly the over-all circuit performance, it was found desirable to designate certain of the important terminal offices as master control points. These offices would have the general responsibility of supervising the maintenance of the over-all circuits and would cooperate with the individual section control points in this work.

The necessity for uniformity in the transmission maintenance of the various circuits indicated the desirability of the adoption of arrangements whereby the operating personnel could be suitably trained in an understanding of their responsibilities and in the uniform interpretation and application of maintenance practises.

The maintenance of satisfactory over-all transmission standards requires the provision at all important points, and particularly at the control points of suitable types of transmission testing apparatus and testboard facilities.

In order to furnish suitable test communication facilities for the use of the plant forces between the control points as well as between these points and the intermediate repeater offices, it will be necessary to provide a special communication system which will allow the various control points to intercommunicate within the range over which they exercise control. A telephone typewriter system with selective control and signaling has been planned as the basic communication system for this purpose.

It is of course evident that the success of an undertaking of this magnitude and importance, will require the close cooperation of all systems concerned working toward one accomplishment; namely, provision of the best grade of telephone service. Up to the present time the progress in the project has been largely the result of the efforts of the Telephone Association of Canada, and it is anticipated that through its continued effort and guidance, this project may be completed successfully and enlarged as future conditions require.

Abridgment of

The Modern Single-Phase Motor for Railroad Electrification

BY F. H. PRITCHARD* and FELIX KONN*
Associate, A. I. E. E. Associate, A. I. E. E

Synopsis.—*The past three years have seen a great increase of activity in the field of a-c. electrification of steam railroads, and consequently much attention has been given to the design of the single-phase traction motors upon which the success of this type of electrification chiefly depends.*

The object of this paper is to describe the up-to-date motors which have been developed to meet the requirements of modern American railroading.

IN order to meet the demands on traction motors incident to announced single-phase electrification programs, considerable developmental work has been done; sample motors have been built and extensively tested and a sample multiple-unit car completely equipped and put into regular passenger service.

"Transformed" Voltage

The biggest handicap that besets single-phase commutator type motors lies in the presence of an alternating voltage between heel and toe of the brushes, which can be corrected at speed but which cannot be avoided at standstill. This is illustrated in Fig. 1 which shows an armature coil undergoing commutation.

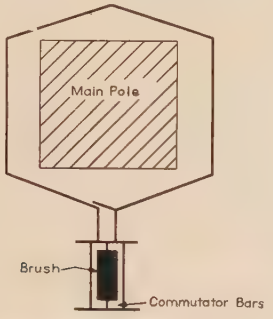


Fig. 1—Developed View of an Armature Coil Undergoing Commutation in Its Relation to the Face of the Main Pole

The torque field winding, which is in series with the armature, produces the torque flux. This flux, instead of being constant as in d-c. motors, is alternating and induces by transformer action a certain voltage in each armature turn. Since the plane of these coils is at right angles to the direction of the flux, this "transformed" voltage has the maximum amplitude in the coils short-circuited by the brushes. If the brush short-circuits two adjacent turns—that is, if it touches three commutator bars—the voltage which is impressed between heel and toe of the brush is twice the voltage induced in each turn.

The transformed voltage is 90 deg. out of phase with the flux (motor current).

Starting Commutation

Fig. 2 shows what happens to a typical brush between heel and toe of which an alternating voltage is impressed. A brush of the size used in the test normally carries a load current of 50 amperes and under overloads will carry up to twice that current.

If a heel-to-toe voltage is applied continuously, glowing will occur from about 2.5 volts up, and the glowing will become violent above the knee; also a severe pitting and softening of the commutator bars will occur. It is obvious that this condition, so far as its effect on the commutator bars is concerned, is most pronounced at standstill.

Practical Limitations of the Transformed Voltage

Earlier designs of single-phase traction motors used heel-to-toe potential of 10 volts or more, and the present motors use values which, roughly speaking, are half this.

It will be seen from the above that even these lower voltages, if maintained indefinitely, would damage the commutator; however, the operating experience abroad with motors designed for these new constants, as well as experience so far gained in this country, indicates that in service the actual time during which these excessive circulating brush currents flow is well within safe limits.

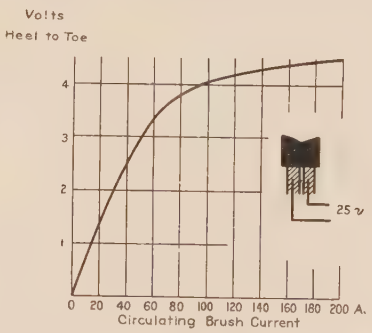


Fig. 2—Brush Volt-Ampere Characteristic

Thus it is seen that the design of a single-phase

*Transportation Engineering Department, General Electric Company, Erie, Pa.

Presented at the Middle Eastern District Meeting No. 2, of the A. I. E. E., Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

traction motor will largely hinge upon the necessity of keeping the transformed voltage from heel to toe of the brush down to a permissible figure. In the motors under consideration, designed for 25-cycle operation, the brushes cannot short circuit more than two coils, and the transformed voltage per turn at standstill does not exceed 3.25 volts for the locomotive motors and 2.75 volts for the multiple-unit car motors.

Number of Brush Holders

These values of transformed voltage per turn at standstill determine the flux per pole under starting conditions. The torque of a motor is proportional to the product of the total armature ampere conductors times the number of poles times the flux per pole.

The last term of this product is determined as we have just shown; thus we see that for an armature with a definite ampere-conductor loading, the starting torque goes up directly with the number of poles; in other words, with the number of brush holders.

Commutator Constants

The above product can be expressed also as follows: Total conductors times current density in the brushes times commutator length times brush thickness times poles times flux per pole.

It should be understood that all single-phase traction motors have armatures wound with one turn per coil; also, that the brush thickness is generally taken as twice the commutator bar pitch; hence, the brush thickness is generally proportional to the expression:

$$\frac{\text{Commutator diameter}}{\text{Total conductors}}$$

Substituting this expression in the last product we find that the starting torque is proportional to the commutator length times commutator diameter times poles times current density in the brushes times flux per pole.

The last two terms are determined by the characteristics of the brushes, and we thus see that the starting torque which can be obtained from a single-phase traction motor is proportional to the area of commutator and to the number of brush holders.

For a given commutator diameter, the new motors have from 50 to 100 per cent more brush holders than earlier motors; and as the disturbance at the commutator is proportional to the square or to some higher power of the flux per pole, the starting commutation is greatly improved.

Running Commutation

When the motor is running, we must deal with two elements of commutation. The a-c. or *quadrature* element of commutation, caused by the transformed voltage, is still present and we shall show how this element can be effectively compensated; we are dealing also with the *in-phase* or *rotational* element of commutation which is of the same nature as the sparking reactance voltage in a d-c. motor.

In addition to the torque field winding the modern single-phase traction motor has a compensating winding and an interpole winding. The interpole winding neutralizes that portion of the armature reaction which is in excess of the compensating winding ampere-turns and in addition, provides a surplus of ampere-turns. This surplus produces a flux under the interpole which in turn develops in the coils undergoing commutation a voltage to neutralize the reactance voltage induced by the reversal of the current—exactly as in a d-c. motor.

Rotational Element of Commutation

It should be strongly emphasized that the commutation of a single-phase motor can be no better on alternating current than it is on direct current. Consequently, in order to design a good a-c. commutator type motor it is necessary to put into it first, all the elements which give good commutating characteristics to a multiple-wound d-c. motor.

For a better understanding of the rotational element of commutation in a single-phase motor, let us consider

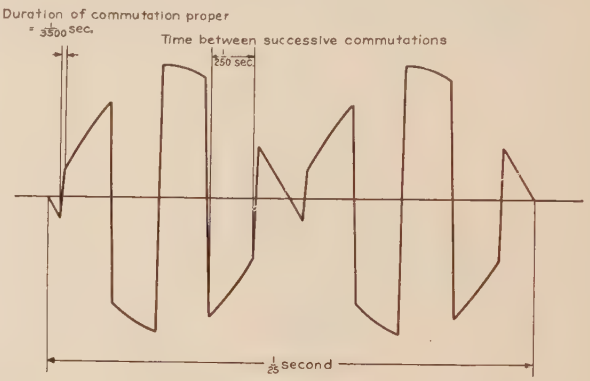


Fig. 3—Variations of the Current in One Armature Conductor

the variations of the current in any armature conductor, (Fig. 3).

Assume that the peripheral speed of the commutator is 6000 ft. per min.—that is, 1200 in. per sec.— and that the brushes are 3/8 in. thick. The reversal of the current takes place in the time required for a point on the commutator to pass a brush, less the thickness of a mica; *viz.*:

$$\frac{0.375 - 0.030}{1200} = \frac{1}{3500} \text{ second,}$$

which is 70 times faster than each reversal of the 25-cycle current.

Fig. 3 shows also that at normal speed in the example chosen, the frequency of commutation (250 reversals per sec.) is much higher than that of the supply; in other words, the fact that we are dealing with 25 cycles should not materially affect the phenomenon of current reversal, which is 70 times faster and which occurs 10 times more frequently.

From the above one could expect approximately the same excess ampere-turns in the compensating and interpole windings to commute 25-cycle alternating

current as for direct-current. This has been proved very conclusively by test.

Transformed Element of Commutation

To accomplish the compensation or neutralization of the transformed element of commutation an external resistor shunting the interpole winding is used. The current in the resistor leads the line current and the current in the interpole winding lags behind it. Fig. 4

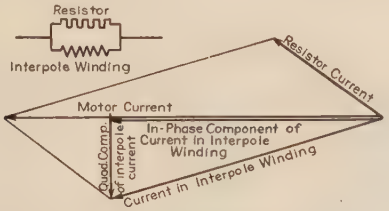


Fig. 4—Vector Diagram Illustrating the Phase Shift Obtained by the Use of the Shunting Resistor

shows how the current in the interpole winding has two components; one in phase with the line current (the magnitude of which is adjusted to take care of the rotational element of commutation), and one 90 deg. out of phase with the line current. This latter component produces a flux which by virtue of rotation generates in the coils undergoing commutation a voltage also 90 deg. out of phase with the line current. This opposes the "transformed" voltage both in phase and (for definite speeds) in magnitude. Resistor losses vary from one to two per cent of the motor input.

The simplicity of this scheme has given it very wide application; practically all modern single-phase traction motors make use of it.

Theoretically, this scheme accomplishes a correct neutralization of the transformed element of commutation at all loads, but only at one speed, because the neutralizing voltage is proportional to the speed while the

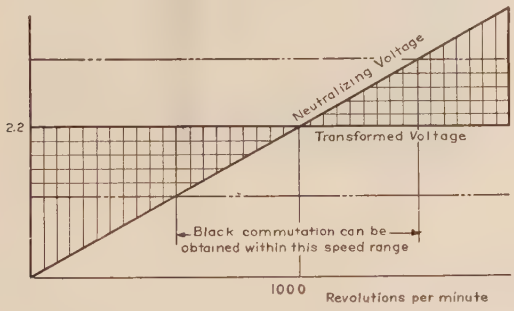


Fig. 5—Effect of Speed on the Neutralization of the Transformed Element of Commutation

Transformed volts per turn. The shaded areas denote under or over compensation

transformed voltage is not affected by the speed at a given load. This is illustrated in Fig. 5. It should be borne in mind, however, that since it takes a certain voltage to produce a spark across the copper-brush contact it is not necessary to have quite perfect neutralization in order to obtain black commutation. The two horizontal lines drawn above and below the 2.2-volt line of ordinate give an idea of the range of uncompensated voltage within which black commutation can be obtained. The lower the flux per pole, the wider is the corresponding speed range—thus improving the starting commutation also improves the running commutation.

Diagram of Connections

The diagram of connections of the modern single-phase traction motor is a very simple one. All windings are in series; the shunting resistor is permanently connected across the interpole winding and there is no change in motor connections throughout the operating cycle.

Motor Voltage

Because of the limitation of the flux per pole, the single-phase traction motor is inherently a low-voltage machine; for example, the rated voltage of a locomotive motor is 225 volts and that of a multiple-unit car motor, with a lower flux per pole, is 170 volts.

If similar constants of design are used (flux per pole, commutator peripheral speed, commutator bar pitch)

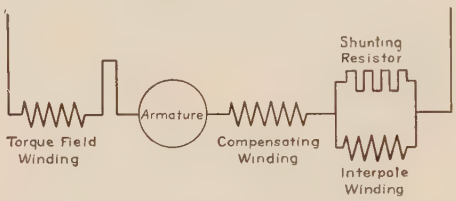


Fig. 6—Diagram of Connections of a Single-Phase Traction Motor

the voltage of machines of different sizes will be the same regardless of the number of poles and brush holders.

Power Factor and Efficiency

At their continuous rating, these motors have a power factor of approximately 95 per cent and an efficiency at the shaft of from 85 to 90 per cent, the higher efficiency figures applying to the larger sized and higher speed motors.

Field Shunting

Under severe starting conditions, and in order to keep the flux—hence, the transformed voltage—below a certain limit, it may be advisable to weaken the main field at starting preferably by means of a saturated inductive shunt. In this case, to develop the required torque the motor must draw a heavier current; but there is a net gain in commutation.

Motor Construction

These features of design have been worked into a 1250-hp. twin-armature locomotive motor and a 220-hp. axle-hung multiple-unit car motor, the construction of which is here illustrated.

In order to find room for the larger number of brush holders, provide proper clearances, and allow for easy inspection and renewal of brushes, a new design of brush-pressure finger has been worked out. At the same time far greater uniformity of brush pressure

between new and worn brushes was incorporated in the design, and resulted in more accurate spacing of brush holders.

The brush holder and supports shown in Fig. 7 have been applied to the motors on the sample multiple-unit

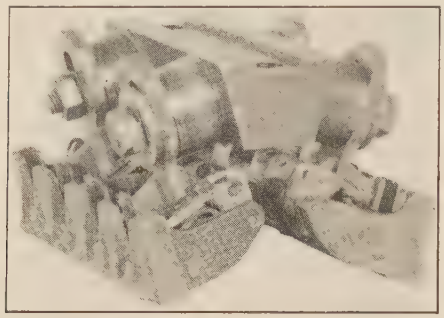


Fig. 7—Brush Holders and Supports with Micalex Insulators

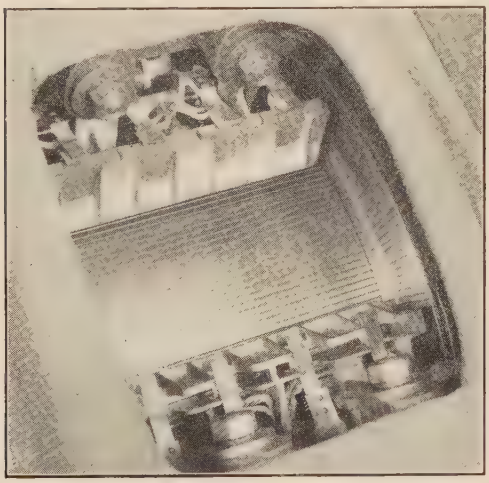


Fig. 8—View Showing the Accessibility of Brushholders

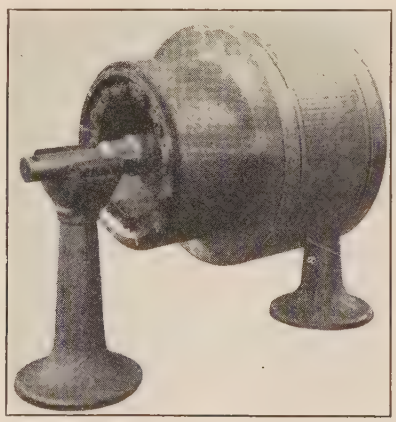


Fig. 10—Rotor of 1250-Hp. Twin-Armature Locomotive Motor

car mentioned earlier; Fig. 8 illustrates their accessibility. Their performance in actual service has been very gratifying; no trouble whatever has developed, the commutators run with a highly polished surface, and the very slight brush wear indicates a saving of at least two years of brush life.

The armature winding is made up of folded cross-over bars which minimize eddy currents. The joints at the back end are silver soldered. There are three coils per slot and to minimize telephone interference and smooth out the interpole flux the armature slots are spiraled one-half slot pitch. Fig. 10 shows the complete rotor. The 18 main poles and interpoles in each stator of the twin locomotive motor are illustrated in Fig. 11.

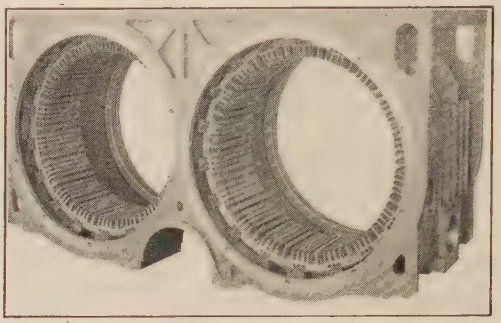


Fig. 11—Magnet Frame of 1250-Hp. Twin-Armature Locomotive Motor with Stator Punchings Ready to Receive the Stator Windings

The modern single-phase motors use grease-lubricated anti-friction bearings resulting in reduced bearing maintenance and maintaining uniform air-gaps which are of considerable aid in commutation.

Capacity

The horsepower capacities of these motors compare very favorably with those of d-c. traction motors of similar weight. For example, a 220-hp. multiple-unit car motor weighs 5600 lb. and a 625-hp. freight loco-

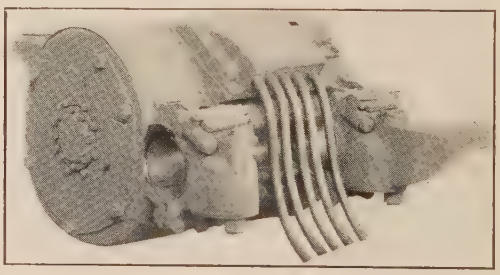


Fig. 12—215-Hp. Multiple-Unit Car Motor

motive motor 14,000 lb. These weights do not include the gear, pinion, gear cover and axle linings.

Conclusion

It will be noted that in the attempt to improve the single-phase motor the greatest effort has been applied to the commutation at starting. Fortunately, this also aids the commutation at speed.

The other problems encountered in the design and construction of single-phase motors are similar to those met with in all other kinds of traction motors.

With this very material improvement in commutation, the single-phase traction motor can be counted upon to give good reliable service with low maintenance cost.

Abridgment of

Progress in the Design of the Single-Phase Series Motor

By H. G. JUNGK[1]

Associate, A. I. E. E.

Synopsis.—*The paper deals with the development of the design of the single-phase series motor and some of the main features in both electrical and mechanical proportions which determine the service capacity in the application of this type of motor to railway electrification.*

Intensive study and development begun in the early part of 1927 resulted in the production of a single-phase series motor with more than enough capacity to meet the present day requirements of the American railroads. A brief description is given of this motor and of some of the novel features which made this recent progress possible. Since this motor was developed, built, and tested, further possibilities of increasing rating or decreasing the size and weight for the same rating have been found and will result in further progress in the design of the single-phase series motor.

THE single-phase series motor for 25 cycles has been developed to the stage where it fulfils the present day railroad requirements,—that is, high horsepowers per axle at high speeds. A high-speed passenger locomotive equipped with single-phase series motors with shunted interpole, developed and built by the Westinghouse Elec. & Mfg. Co., has been operating since July 1930. The continuous rating is more than 1000 hp. per axle at 56 mi. per hr. In service, the locomotive has eclipsed the performance for which it was originally designed and has clearly demonstrated that it is now practical to build a 25-cycle single-phase locomotive for as high as 75,000-lb. axle loading, geared to operate at a maximum sustained speed of 90 mi. per hr. The characteristic curves are shown in Fig. 1.

This development was started more than three years ago in spite of the fact that at the time opinions were expressed that such a design was impossible. The outstanding features which made this possible were: (a) Roller bearings; (b) commutators and armature windings designed to operate at higher peripheral speeds than heretofore considered good practise; (c) more compact ventilating scheme; (d) improved quality of magnetic material; (e) rolled-steel housings and welded frames; (f) the disk spring commutator; and (g) improved designs of gears, pinions and mechanical drive.

Considerable credit is to be given to the European designers and manufacturers of single-phase railway apparatus in Germany, Austria, Switzerland, and Sweden, especially to the German engineers who were the first to apply generally roller bearings to locomotive motors in order to take advantage of the higher peripheral speeds on 16⅔-cycle single-phase series motors.

Once the fact was demonstrated that such higher ratings were also possible on 25-cycle single-phase series motors, a number of further improvements have been found which permit the design of motors of even larger capacity in the same space and weight. The development of the single-phase commutator motor cannot be attributed to any one manufacturer or group of individuals. Its development is nearly as old and as broad as that of alternating current. The purpose of this paper is to describe briefly the history and how the evolution led to the present day designs.

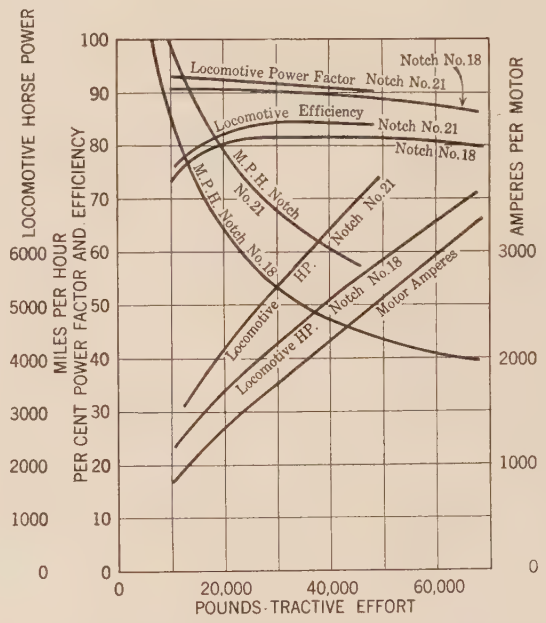


FIG. 1—PERFORMANCE CURVE OF PASSENGER LOCOMOTIVE EQUIPPED WITH FOUR NO. 422-A SINGLE-PHASE COMMUTATOR MOTORS

Includes input to all auxiliary apparatus and gearing

The single-phase commutator motor, although the fact is not generally recognized, followed closely the conception of the synchronous motor which was the first a-c. motor. The original designs were patterned after the d-c. series motor. The first appearance in literature was the mention of the possibility of such

1. Design Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Southern District Meeting No. 4, of the A. I. E. E., Louisville, Kentucky, November 19-22, 1930. Complete copy upon request.

a motor in 1884 by Alexander Siemens. This was followed in 1887 by the experiments and attempts of Elihu Thomson with the repulsion motor. Although not entirely successful the idea was followed up and in 1892 E. Arnold brought out a more successful repulsion motor which embodied the principles of the repulsion, the double-feed, and the series motor. The difficulties of commutation on the higher frequencies at this time, together with the advent of the induction motor, pushed the a-c. series motor into the background until after 1900.

The first real impetus to a practical application of the series motor for traction purposes came in 1902 when B. G. Lamme brought forth a single-phase series motor for railway application and emphasized the importance of a low frequency, having chosen 15-cycle motor. At about the same time, (1903) independent developments in Europe brought out a test locomotive for the Prussian State Railways as a result of the endeavors of Winter, Eichberg and Latour.

The first outstanding electrification was that of the New York, New Haven, and Hartford Railroad in 1907 for which Lamme and Storer designed and built resistance lead series motors which are running successfully today. The principal objectives of Lamme for this development of the a-c. series motors—notwithstanding certain limitations in design—were,

a. To make use of the outstanding advantage of the series motor for traction purposes in conjunction with the a-c. high-voltage contact system which permits the maximum concentration of power in a given section with the minimum size of conductors and supporting structure and substation capacity, as well as high transmission efficiency.

b. To obtain a motor with minimum power requirements for acceleration.

c. To obtain a motor tractive efforts of which could be maintained within limits over the entire speed range by varying the voltage of the motor, irrespective of motor combinations, by change in transformer taps, thus obtaining a maximum output.

Several outstanding features resulted from this New Haven Electrification:

a. Some of the passenger locomotives were operated at speeds of over 100 mi. per hr. but at a limited capacity because the axle loading was around 40,000 lb. (and gearless motors were used).

b. The individual axle drive of the flexible quill type was developed for

1. Gearless motor (No. 130 motor).
2. Geared single motor (No. 403 motor).
3. Geared twin motor (No. 409 motor).

The gear twin motor with flexible quill drive has made it possible to design for considerably more horsepower per axle with smaller high-speed motors and narrow gear face.

c. Single-phase multiple-unit cars.

Considerable independent development took place in Europe at this time; the work of Doctor Behn Eschenberg, R. Richter and M. Latour produced the series motor with the compensating winding and series interpole shunted by resistance. The limitations of short-circuit currents in coils undergoing commutation were investigated and the combination of a brush, two-bar pitches wide with a limit of 7 volts from tip to tip, was established, limiting the maximum flux per pole at start to

1.6 megalines at 50 cycles
3.2 megalines at 25 cycles
5.3 megalines at 15 cycles

The first experimental series motor with interpoles which the Westinghouse Elec. & Mfg. Company built was in 1911 (411). This motor had low flux per pole and interpoles shunted with resistance. Mr. Hellmund, in his tests with this motor, found most of the relations which characterize the designs of today but at that time could not take full advantage of them because both switches and reversers were then too big and too heavy to handle the larger currents economically.

The double-feed motor with repulsion start worked out better with the available control apparatus and this type of motor was applied to multiple-unit cars. Considerable development of the double-feed motor took place, Arnold, Richter, Hellmund, Alexanderson, Punga, Latour and others doing considerable to advance the art. The original and major number of motors used on multiple-unit cars of the Pennsylvania Railroad at Paoli are of the double-feed type (412-A) and the armatures of these motors were the first to be wound with the split-throw[2] or fractional-pitch windings to improve commutation.

The World War retarded progress a second time—more in Europe than in America of course—and it was not until 1919-20 that multiple-unit car equipped with a single-phase series motors with resistance shunted interpoles (415-A) was tried out in service on the Paoli cars at Philadelphia. Weakening of the exciting field at start was tried on this equipment by connecting the fields of two motors in parallel at start and then changing to field in series for the running connection. A second trial equipment (419) in 1924 was tried in service with the field shunted by a reactor to reduce the field strength at start. This motor is still operating satisfactorily in daily service.

In 1923-24 a large locomotive motor of the single-phase series type with shunted interpole was designed and built for gear and side rod drive (on the Pennsylvania Railroad).

As Europe recovered from the war, considerable progress was again made in Germany, Austria, Switzerland and Sweden, where the single-phase systems were adopted as standard for electrification; the single-phase series motor with shunted interpole was generally applied with a definite trend toward individual axle drive; the double-feed motors and resistance lead

2. Patent No. 1298705, R. E. Hellmund, April 1, 1919.

motors were set aside; the necessity for smaller motors with greater capacity brought on an intensive develop-development, both in drive and in mechanical construction; and attempts were also made to exceed the established limits in electrical design.

In Germany, Siemens-Schuckert concentrated on Geh. Reichel's objective of a single-axle-hung motor for passenger locomotives, and succeeded in developing 600 hp. per axle with 44,000 axle loading for a maximum speed of 62 mi. per hr. The application of roller bearings and an increase in peripheral speed of commutators to 9000 ft. per min. were the main features which made this possible.

A. E. G.[3] engineers directed their efforts toward producing the Kleinow locomotive with twin motor per axle drive and succeeded in producing a locomotive with 700 hp. per axle within the limits of 44,000 axle loading and 60 mi. per hr. maximum speed.

In Austria, Siemens-Schuckert produced a passenger locomotive with vertical motors and although a novel departure in drive construction, it has given good results.

Brown Boveri built locomotives with their single motor per axle drive and omitted the compensating winding in the pole face but used the shunted interpole in an effort to increase the number of poles on the motor. The outstanding result of their work was to develop a compact design of brush holder so as to place the maximum number around the commutator. This was reflected in the motor built for American application, where 24 holders were placed around a 48-in. commutator, and later, 10 holders around a 17-in. commutator.

In 1926-27 the problems in connection with the electrification of some of the larger American trunk lines became more active. Our 25 years' experience in a-c. electrification and our knowledge of the 16⅔-cycle development in Europe gave us considerable data with which to proceed. The handicaps of 25 cycles over 16⅔ cycles is of fundamental importance in motor design. Starting conditions of commutation definitely limit the flux per pole. For the same voltage between commutator bars, the 25-cycle motor can have only ⅔ the flux per pole of a 16⅔-cycle motor. Hence for the same torque a 25-cycle motor must have either 3/2 times the armature ampere turns or 3/2 times as many poles as a 16⅔-cycle motor, or a partial increase in both armature ampere turns and poles to make up for ⅔ the flux. In addition to this, the axle loading in Europe on the 16⅔-cycle motors is not more than 44,000 lb. while here in America with 25-cycle, the axle loading is as much as 75,000 lb. Hence our problem here is to design for $\frac{75000}{44000}$ or 170 per cent of the axle loading and starting tractive effort with ⅔ the flux per pole and either 3/2 the poles or 3/2 the armature ampere-turns required in Europe. In addition to this, the maximum locomotive speed in Europe is 62 mi. per hr. (although this may be increased to 75-80 mi. per hr.) while here in America we are designing for 90 to 100 mi. per hr. maximum. Hence with 170 per cent of the starting tractive effort per axle, 150 per cent of the maximum running speed with ⅔ the flux per pole and either 3/2 the poles or 3/2 the armature ampere-turns, the proportions of our motors differ somewhat from those of the European motors.

Our engineers studying the problems of electrification economies, application, etc., put before the design engineers the problem of designing and building a motor suitable for freight service as an axle-hung motor and suitable for passenger services as a twin motor with flexible quill drive with motor parts interchangeable, which entails design difficulties. Railroad limitations at the time were 60,000 to 65,000 lb. axle loading, 45-50 mi. per hr. maximum speed for freight, and 90-100 mi. per hr. maximum speed for passenger locomotives for operation on 25 cycles. Designs were worked up and the first test motor was built for 25 per cent adhesion at 60,000 lb. axle loading, geared for 90 mi. per hr. maximum speed with a continuous rating of 1000 hp. per axle at the rail at 55 mi. per hr. The motor was tested early in 1928 and the fact was clearly demonstrated that such a capacity was possible with 72-in. drivers. A change in ventilation was then made with the result that a motor rating of 1220 hp. per axle at 56 mi. per hr. could be obtained by an increase in current without exceeding A. I. E. E. temperature limits.

Following these tests, twin motors were built in mechanical parts designed to mount in a locomotive. Development was then concentrated on the commutator construction and the new disk-spring type was developed in which the bars are held together by the force exerted by a disk spring pressing against the V ring. The field of the motor is shunted at start and has the same flux at standstill as at continuous rating with the present locomotive control scheme. A ventilation scheme was developed whereby the arms of the spider and coil support provide an internal blower which assists in the circulating of the air through the armature passages.

To eliminate the difficulties of securing adequate cast steel frames of the size required, a new welded rolled-steel frame was developed. Housings and commutator parts, also of rolled steel, were applied so that the motor would occupy less space and as they are relatively lighter and stronger. The motor frame and housings were dimensioned and designed to take electrical parts of either 12, 14, 16, 18 or 20 poles. The original motor was designed for the minimum number of poles in order to get the maximum voltage and minimum current. This required a design wherein three commutator bars are spanned by the brush in order to get a brush of sufficient mechanical strength and smooth riding qualities on the commutator.

The motors for the existing locomotive were ready

3. Allgemeine Elektricitaets Gesellschaft.

in the latter part of 1929 and the locomotive was placed in service the first week in July 1930. The actual weight on drivers is higher than the 60,000-lb. axle loading for which the motor was designed; hence the motor will be tested with more severe starting conditions than originally contemplated. The performance of the locomotive has exceeded expectations. The experience gained through the operation of this locomotive in service with the increased axle loading, and the knowledge and experience gained in the past three years, make it possible to design for as high as 75,000-lb. axle loading at the same speeds.

The required capacity of any motor applied to a locomotive or car is determined by starting tractive effort and the maximum sustained running speed at which the locomotive or car must operate. The gear ratio and wheel size must be so proportioned that the commutator speed will be within safe limits at the maximum sustained running speed of the locomotive. The maximum tractive effort which may be obtained with this gear ratio and wheel size is limited by the current-carrying capacity of the brushes and commutator or armature windings. The continuous capacity is then the output at some voltage and speed with this gear ratio, wheel size and current-carrying capacity at which the temperatures do not exceed certain safe values.

For multiple-wound armatures, gross tractive effort equals,

$$\frac{\text{flux per pole} \times \text{brush current density} \times \text{poles} \times \text{peripheral speed commutator}}{1414 \times \text{mi. per hr.}} \times \frac{\text{width of brush}}{\text{bar pitch}} \times \text{active length of commutator} \times \cos\alpha \times \text{gear efficiency.}$$

where active length of commutator is the total length of brushes in a brush holder.

The gross tractive effort can be converted into net tractive effort at the rail by deducting rotational losses and gear losses which are of the order of 5 to 10 per cent. At standstill, the cos α may be of the order of 90 per cent but is practically unity above $\frac{1}{4}$ speed.

The maximum peripheral speed of a commutator is a mechanical limitation; the dimensions of the individual bars and the method of holding them together determines the safe maximum speed at which the commutator may rotate without overstressing the parts. Disk spring commutators have been built to operate at 9000 ft. per min.

The flux per pole at start, the permissible current density in the brush, and the maximum number of bars spanned by a brush at any time, are all very closely related and depend entirely on the characteristics of the carbon brush. The resistance of contact of any carbon decreases with temperature rise. On brushes with high contact drop, the circulating current in the coil short-circuited by the brush varies about as the square of the voltage induced in the coil, reaching a critical condition between 3.5 and 3.75 volts above which the current increases very rapidly with a slight increase in voltage. Since this characteristic is caused by local heating it is evident that with line current also carried by the brush, the voltage induced in the short-circuited coil must be held below this critical point. Tests have shown that some carbons will stand as high as 2.9 volts between bars and a load current density of 150 amperes per sq. in., where the brush is two bar pitches wide and is in contact with three bars most of the time.

If we substitute these values in the equation for tractive effort we have at 25 cycles,

$$\text{Gross tractive effort at start} = \frac{2.6 \times 150}{1414} \times \text{poles} \times \frac{9000}{\text{Max. mi. per hr.}} \times 2 \times \text{active length of comm.} \times \cos\alpha = \frac{4960 \times \text{poles}}{\text{Max. mi. per hr.}} \times \text{active length of commutator} \times \cos\alpha.$$

Therefore with the tractive effort required for starting and the maximum mi. per hr. for sustained running speeds the poles and active length of commutator may be readily determined. This brings us to the requirements of the car or locomotive.

On multiple-unit cars the weight on the driving axles will probably not exceed 40,000 lb. Since sand is seldom used, the maximum adhesion will not be over 18 per cent giving a possible starting tractive effort of 7200 lb. per axle. Geared at 70 to 75 mi. per hr. it would be possible to accelerate such a car at one mi. per hr. per sec. with only one axle driven by a 12-pole motor with 10-in. active commutator. With motors on two axles it would be possible to haul a trailer.

For a locomotive of 60,000 lb. axle loading and a starting adhesion of 25 per cent each axle would exert 15,000 lb. tractive effort at start. This would require a 12-pole motor with a 12-in. commutator to bring the locomotive to 45 mi. per hr. with one motor per axle. Two motors per axle would give a maximum speed of 90 mi. per hr.

Assuming the maximum weight per axle held at 75,000 lb., then at 30 per cent adhesion, each axle could exert 22,500 lb. tractive effort at start. This would require 18 poles and 12 in. of commutator length to bring this locomotive to 45 mi. per hr. maximum speed, and with a twin motor of the same dimensions, the locomotive could be operated at 90 mi. per hr. maximum speed.

The design of the locomotive then becomes one of grouping the required number of axles under a cab to give the most economical operating unit. This grouping depends on the special size of driver necessary and this is where the dimensions of core and windings play an

important part. At the present time twin motors can be built to go on 72-in. wheels and develop 25 per cent adhesion at start, geared for 90 mi. per hr. maximum running speed. With the developments now under way, however, this wheel size may be brought down to 68 in., or the maximum speed on 72-in. wheels may be raised if desired, since the experience of the last few years indicates that considerable further improvements can be made to permit the application of smaller motors for the same tractive efforts or of the same size of motors for greater tractive efforts.

In conclusion, it should be noted that our new design of series commutator motor and control equipment for 25-cycle railway electrification has exceeded expectations as to hp. per axle. With the new motor a four-axle locomotive has developed more service capacity than was expected with the six-axle locomotive which was proposed four years ago and which was then considered to be a marked improvement over existing designs. Further, it should be noted that this new design, while representing an entirely new analysis and proportioning or arrangement of the various essential parts to obtain better power factor, efficiency, commutation and speed-torque characteristics, is nevertheless based on the sure foundation of nearly 30 years of constant practical experience in a-c. electrification and over three years of intensive development work and testing of this new design.

Abridgment of

Circuit Breaker Recovery Voltages

Magnitudes and Rates of Rise

BY ROBERT H. PARK* and WILFRED F. SKEATS†
Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*This paper shows the conditions affecting the magnitude and rate of rise of recovery voltage at the terminals of an oil circuit breaker upon interruption of a short circuit; also explaining their effect in quantitative terms.*

The most common locations, and a rough idea of the magnitude of the capacitances affecting the rate of rise of recovery voltage for various types of short circuit, are indicated, and calculations of the recovery voltage curve for several representative cases at both low and high voltages are presented. In some cases cathode ray oscillograms are given for comparison with the calculated curves.

While at present no systematic data regarding the effect of the rate of recovery voltage rise upon circuit breaker operation appear to be available, several tests showing a very pronounced effect—some of them made by the authors and some by others—are reported briefly.

There are presented factors whose numerical value takes into account: the number of phases involved in the short circuit and the ground connections of short circuit and generator; the decrement of short-circuit current previous to interruption; and the effect of unequal reactances in the direct and quadrature axes of synchronous machines. The paper also indicates how one may calculate the effect of displacement and initial load current, besides briefly discussing the effect of saturation. Magnetic oscillograms to verify the most important of the points brought out are shown.

A discussion of the method by which overvoltages are built up during the interruption of transmission line charging currents is presented at the end of the paper.

Introduction

WHILE the duty on circuit breakers is commonly expressed in terms of the circuit voltage previous to short circuit and the magnitude of the current in the arc, it is a matter of experience that in practise other circuit characteristics may affect the duty to an important extent.

For instance, tests made on the system of the Northern States Power Company at St. Paul, Minnesota, during the month of September 1925 brought to light a case of marked difference in the difficulty of opening the circuit, depending on the source of power employed.

This difference was between three-phase tests with breaker neutral ungrounded when connected through a 43-mi., 110-kv. line to an 18,750-kv-a. turbine generator at the Riverside Station; also similar tests, when directly-connected to three 6600-kv-a. hydroelectric generators at the Wissota Station. Referring to Table I it will be seen that in spite of the slightly lower voltage, much greater difficulty was encountered with direct connections to the bus at Wissota.

Table I

Source of power	Riverside	Wissota
Number of tests made	2	5
R. m. s. line-to-line volts before short	15,000	13,200
Average initial r. m. s. current in the arc	1,400	1,420
Inches of arc	1.2	4.8
Half cycles of arc	3.5	10.0
Maximum pressure, lb. sq. in.	6.5	36.0

As a result of studies made at the time of these tests, it became evident that the effects could be explained in terms of the brief "kicks" which occur in the recovery voltage, and the time delay required for their establishment.

While several investigators have emphasized the

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significance of these kicks, no very comprehensive analysis has been presented to show how they are affected by the various types of apparatus which are found on transmission systems. This paper attempts to present such an analysis.

The phenomena of recovery voltage may be divided into two parts—low-frequency effects and high-frequency effects. The low-frequency effects comprise those arising from the type of short circuit, decrement, displacement, and flux distribution in rotating machinery, and include most of the factors determining the magnitude of recovery voltage. The high-frequency effects are attributable to the capacitances of the various parts of the system to ground; they are responsible for an overshoot, (often to double the value predicted from low-frequency considerations) and include all of the factors determining the time required

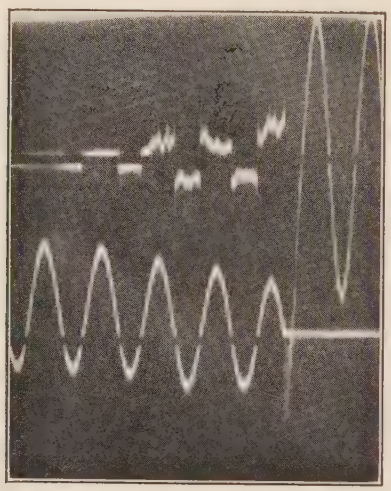


Fig. 1—Oscillographic Record of Current and Voltage of the First Phase to Clear of a Three-Phase Short Circuit at 13,200 Volts on a 100,000-Kv-A. Alternator, Ungrounded

External reactance per phase ten times generator subtransient reactance

to reach the maximum value. It is convenient to consider these two types of phenomena separately: The low-frequency phenomena will be treated first.

Low-Frequency or Magnitude Phenomena

A. Number of Phases Involved and Ground Connection of System; Effects of Stationary Apparatus, No-Load

1. Single-Phase Short Circuits. Where the short-circuit impedance of stationary apparatus is much greater than that of rotating machinery, for single-phase short circuits, either line-to-ground or line-to-line, the voltage after interruptions except for high-frequency effects, is the same as before establishment of the short circuit.

2. Three-Phase Short Circuits. The general expression for the recovery voltage of the first phase to clear of a three-phase short circuit (where the effect of stationary apparatus predominates) is, in terms of symmetrical phase sequence components,

$$e = \frac{3\,E\,Z_0\,Z_2}{Z_1\,Z_2 + Z_0\,Z_1 + Z_0\,Z_2}$$

where E is the phase-to-neutral voltage existing before short circuit.

If either the generator or the short circuit is ungrounded, Z_0 is equal to infinity, and in stationary apparatus, $Z_1 = Z_2$. Making these substitutions, for the first phase to clear of an ungrounded three-phase short circuit or of any three-phase short circuit on an ungrounded system,

$$e = \frac{3}{2}\,E$$

Fig. 1 shows an oscillogram taken on the first phase to clear of a three-phase short circuit at 13,200 volts on a 100,000-kv-a. alternator, ungrounded, with reactance in series per phase equal to about ten times generator subtransient reactance.[3] The ratio of the first peak of recovery voltage to the crest voltage existing before short circuit, (as determined from a voltmeter), is 1.47.

If both the system and the short circuit are solidly grounded, Z_0 may have a low value and the recovery voltage of the first phase to clear may be very low; or, on the other hand, Z_0 may be equal to, or greater than, Z_1, and the recovery voltage equal to, or greater than, the voltage existing before short circuit.

In systems grounded through a neutral impedance, the neutral impedance is usually high enough so that the recovery voltage is practically that obtained on an ungrounded system.

3. Two-phase-to-ground Short Circuits on an Impedance Grounded System. For the first phase to clear of a two-phase-to-ground short circuit, the recovery voltage varies from a theoretical minimum of half line voltage with negligible zero-phase sequence impedance, to line voltage with very high neutral impedance, if the neutral impedance has the same phase angle as the line impedance. If the neutral impedance phase angle differs from that of the line impedance, the recovery voltage for one phase is somewhat decreased while that for the other is increased.

B. Effects Arising From Rotating Machinery at No-Load

Fig. 2 represents the decrement of the a-c. component of current through the breaker during a severe three-phase fault. The recovery voltage for the first phase to clear of a three-phase short circuit at the machine terminals, (if either the machine or the short circuit is ungrounded or has a high ground impedance) is

$$e = 1.5\,x_q''\,i$$

where x_q'' = the quadrature subtransient reactance of the machine.

3. See bibliography, complete paper.

For a three-phase short circuit at the machine terminals at no-load,

$$i'' = \frac{E}{x_d''}$$

where E = the leg voltage of the machine before short circuit, and x_d'' = the direct subtransient reactance of the machine.

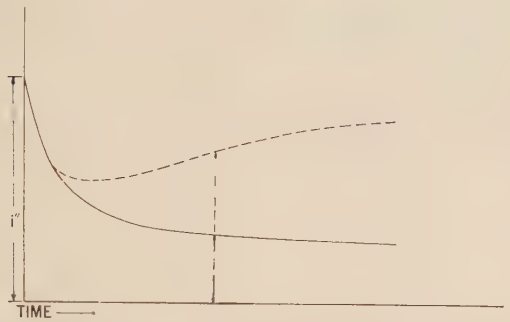


FIG. 2—DECREMENT OF THE A-C. COMPONENT OF CURRENT DURING A SEVERE FAULT

i'' = initial inrush current
i = current at time of clearing
Full line refers to hand-regulated machines, and dotted line to machine with high-speed excitation

Thus the recovery voltage formula may be written

$$e = 1.5\,E\,\frac{i}{i''}\,\frac{x_q''}{x_d''}$$

If the short circuit is not at the machine terminals, the quantities x_q'' and x_d'' should be replaced by quantities s_q'' and s_d'' where s_q'' and s_d'' are the reactances of

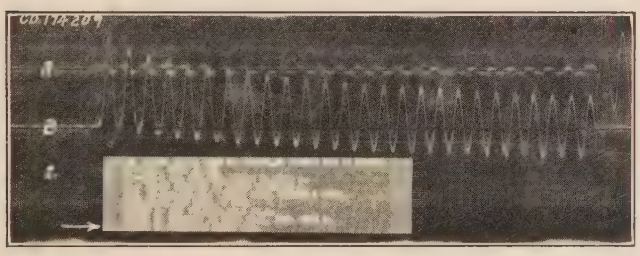


FIG. 3—OSCILLOGRAPHIC RECORD OF CURRENT AND VOLTAGE OF THE FIRST PHASE TO CLEAR OF A THREE-PHASE SHORT CIRCUIT AT 13,200 VOLTS

On a 100,000-kv-a. generator, without an amortisseur winding, operating with the neutral ungrounded. No external reactance

the system using respectively quadrature and direct subtransient reactances as the reactances of the generators.

The recovery voltage for the first phase to clear of a three-phase short circuit may therefore be considered as the leg voltage of the system before short circuit, modified by three factors: (1) A factor k_g, which depends upon ground connections; (2) a decrement or "change in excitation" factor, k_δ; and (3) a quadrature reactance factor, k_q.

In the complete paper the values of k_g, k_δ, and k_q for all types of short circuit are given.

Average values of $\frac{x_q''}{x_d''}$ for machines of various types are shown by Table II.

TABLE II
QUADRATURE REACTANCE FACTORS

Types of machine	$\frac{x_q''}{x_d''}$
Turbo-alternators	
a. Laminated rotor	2.5
b. Solid rotor	1.4
Salient-pole machines	
a. Without amortisseur	2.3
b. With amortisseur	1.1
Induction motors	1.0

C. *Effect of Displacement*

The existence of a large d-c. component in a short-circuit current may cause the recovery voltage wave to

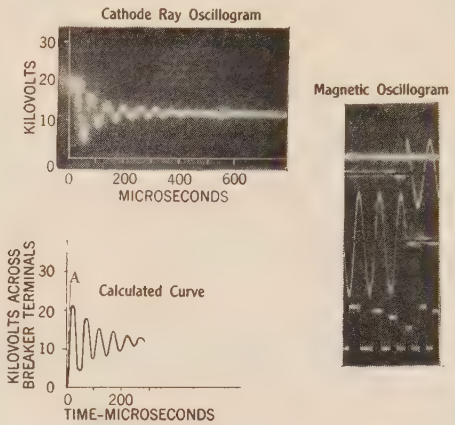


FIG. 4—CATHODE RAY AND MAGNETIC OSCILLOGRAPHIC RECORDS AND CALCULATED CURVE FOR RECOVERY VOLTAGE OF THE FIRST PHASE TO CLEAR OF A THREE-PHASE GROUNDED SHORT CIRCUIT AT 14,500 VOLTS

On an ungrounded 100,000-kv-a. alternator with three ohms external reactance in series per phase

start near the zero point instead of at its crest. Thus considerably reducing the instantaneous value of recovery voltage.

D. *Effect of Initial Load Current*

The recovery voltage depends upon the current through the switch. This may include load current as well as fault current. The formulas given under part *C* may still be used in this case, if i is taken as the total reactive current through the switch.

E. *Effect of Saturation*

The presence of flux at a density near saturation in the teeth and the end of the pole operates to cut down the permeability of these parts to a change in total flux in any direction. Quadrature axis flux has a greater length of path through the end of the pole than has direct axis flux. Thus saturation probably tends to decrease the value of both quadrature reactance and the quadrature reactance factor.

High-Frequency or "Rate-of-Rise" Phenomena

Qualitative Discussion of Important Types of Apparatus

Practically all of the high-frequency phenomena attendant upon the build-up of recovery voltage are attributable to the capacitance to ground of apparatus between the circuit breaker terminals and the principal part or parts of the reactance limiting the short-circuit current.

If any transmission lines or cables are connected

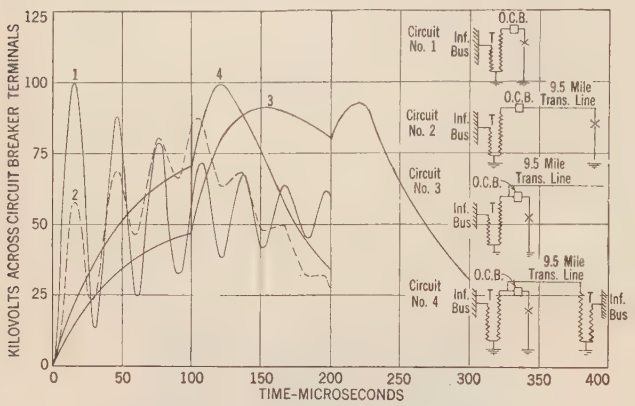


Fig. 5—Calculated Recovery Voltage Curves Following A Single-Phase Line-to-Ground Short-Circuit at Points Marked *X* on Circuit Diagrams

System voltage: 66,000
Capacity of transformer in each case: 20,000 kv-a. per phase
Transformer reactance: 10 per cent
Transmission line surge impedance: 400 ohms
Length of transmission line: 9.5 mi.

between the breaker and the principal part of the reactance, their capacitance determines the rate of rise of recovery voltage except that if the short circuit

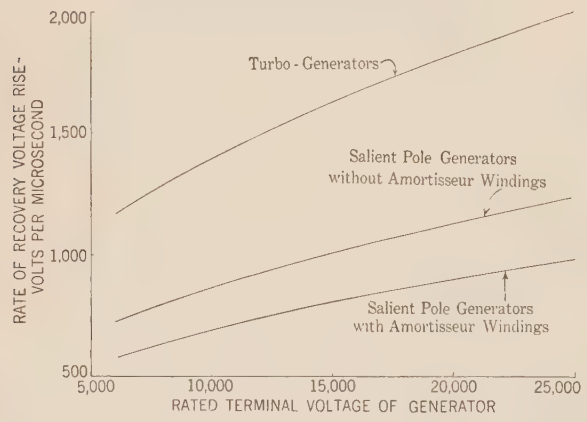


Fig. 6—Rates of Recovery Voltage Rise for Three-Phase Ungrounded Short Circuits at the Generator Terminals

is at the generator terminals the capacitance of the generator must be considered.

If no transmission line or cable is connected, unless the short circuit is at the generator terminals, the capacitance of high-voltage bushings, station bus structure, transformer windings, and current limiting reactors must be considered. Capacitance from these sources is not likely to be more than 0.02 μf., and may be much less.

Between the copper of its windings and the iron of its stator laminations, a rotating machine has a capacitance usually between one-tenth and one μf. This capacitance determines the frequency and rate of rise of recovery voltage in the case of a dead short circuit on the machine.

Recovery Voltage Rates on High-Voltage Systems

The extreme values of frequency and rate of rise of recovery voltage at the high side of a transformer are experienced when there is no apparatus of appreciable capacitance (say 0.002 μf. or more) on either the high or low side of the transformer.

Under this condition, assuming an effective capacitance to ground of 0.001 μf. per transformer winding,

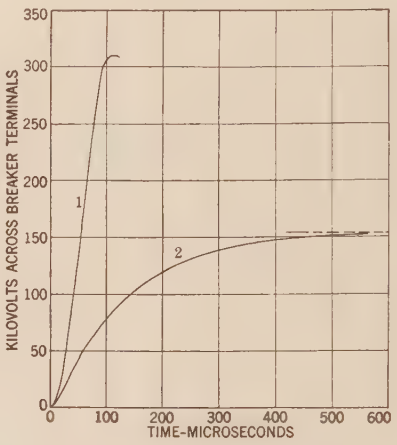


Fig. 7—Recovery Voltage Curves for Tests on Experimental Explosion Chamber Breaker

Curve No. 1 is for standard 110-kv. test circuit; Curve No. 2 is for standard 110-kv. test circuit modified by the connection of a 1000-ohm resistor across the breaker terminals

the frequency and rate of rise are given by the equations.

$$f = \frac{3200}{\text{kv.}} \sqrt{\frac{\text{kv-a.}}{n\,k_q}} \text{ cycles per second}$$

and

$$r = 20\,k_q\,k_\delta \sqrt{\frac{\text{kv-a.} \times k_q}{n}} \text{ volts per microsecond.}$$

where

Kv-a. denotes the initial short-circuit kv-a. per phase (neglecting the d-c. component),

Kv. denotes the leg voltage of the system in kv. before short circuit,

and n denotes the number of transformers in parallel.

The beneficial effect of a capacitance to ground connected between the high side of a transformer and the circuit breaker is strikingly presented in Fig. 5, where calculated recovery voltages at the high side of a 20,000 kv-a., 38.1-kv. line-to-ground transformer following a single-phase line-to-ground short circuit are shown for the four circuits illustrated, the low tension winding of the transformer being assumed connected to an infinite bus in each case.

Recovery Voltage Rates on Low Voltage Systems

On the basis of average values for the design constants of a rotating machine, the rate of recovery voltage rise for the first phase to clear of an ungrounded three-phase short circuit is given with reasonable accuracy by the curves of Fig. 6.

Effect of Nature of Recovery Voltage on Breaker Operation

The tests made on the system of the Northern States Power Company were mentioned in the introduction. In addition, tests have been made under controlled conditions in the manufacturer's testing plant.

The breaker used in one investigation was a 110-kv. (63.5-kv. to ground) explosion chamber breaker. It was tested on the standard test circuit and also on a modification involving the connection of a 1000-ohm resistor across the breaker terminals.

On the standard test circuit the breaker cleared on the 66-kv. connection, (requiring from 58 to 73 per cent of its total contact separation) and failed to clear on the 88-kv. and 110-kv. connections. With the resistance connected across the breaker terminals, the breaker cleared consistently, not only on the 88-kv. and 110-kv. connections but also on the 132-kv. connection, the maximum arc length being only 58 per cent of the total stroke.

Recovery voltage curves for the two conditions are shown in Fig. 7, that for the standard circuit being taken from a cathode ray oscillogram, and the modification due to the connection of the resistor being calculated.

A decrement factor of 1.0 is assumed for both curves.

ACKNOWLEDGMENT

The authors are deeply indebted to Mr. G. F. Davis and his testing force for their cooperation in obtaining the oscillograms; Mr. R. F. McAtee operated the cathode ray oscillograph; Mr. H. F. Marples has done much of the numerical work and drew many of the figures; and Mr. V. C. Kauffman has contributed the greater part of the mathematical work in the appendixes.

The Development of Arc Welding Apparatus
As Indicated by the Oscillograph

BY C. J. HOLSLAG[1]
Member A. I. E. E.

THE development of arc welding apparatus to its present efficient form has been a gradual process of evolution. In the early days all that was thought necessary for arc welding was a source of power which would supply the proper amperage; the ordinary 110-volt line, transformer, or d-c. generator, were considered entirely adequate. These sources of power were used in connection with a resistance or reactance to control the current to the desired value; in fact, at that time the proper amperage was not definitely known. In general it might be stated that the values of current used, particularly for heavier material, was entirely too low.

Unfortunately, even now some welding is being done from a high-voltage circuit with merely a resistance to control the arc. Not only is this a very inefficient means of power supply because of the wide fluctuations in the voltage but it also is difficult to control the current in the arc. The useful power when employing, for example, a 500-volt street car circuit, may be as low as5 per cent, the rest being wasted.

The energy in the welding arc which is used in melting and vaporizing the electrode and fusing the surfaces to be joined, is dependent upon the voltage and current of the arc. This of course is expressed in watts. If proper consideration is not given to the product of the two, such terms as "constant current" and "constant voltage" are often misleading.

It was formerly considered that in the resistance control of arc welding, the higher the applied voltage, the better the welding conditions. It is true that an abnormally high voltage enabled the operator to draw a longer arc; it is generally recognized, however, that a long arc results in a porous oxidized deposit and a consequently poor weld. Similarly, if too much reactance were used to obtain a long, stuttering, large, globule arc, poor welds could result.

Whether the metal passes through the arc in the form of vapor or molten globules of metal, or both, the ideal welding condition is produced when the arc is maintained with continuity and smoothness.

The A. I. E. E. STANDARDS for Arc Welding Apparatus define the various types of welding generators as follows:

"Constant Voltage Welding Source.—A source which automatically maintains its voltage within 5 per cent of the rated full-load setting over the range from full load to no-load and has a time of recovery of not more than 0.3 second.

"Constant-Current Welding Source.—A source which when adjusted to give rated current output with normal arc voltage will automatically maintain this current output within 5 per cent of the rated value with a variation in arc voltage of 10 per cent above or below

1. Chief Engineer, Electric Arc Cutting and Welding Co., Newark, N. J.

the normal arc voltage, and has a time of recovery of not more than 0.3 second.

"Constant-Power Welding Source.—A source which when adjusted to give rated power output with normal arc voltage will automatically maintain this power output within 5 per cent of the rated value with a variaton in arc voltage of 10 per cent above or below the normal arc voltage and has a time of recovery of not more than 0.3 second."

When these facts about long arcs became generally

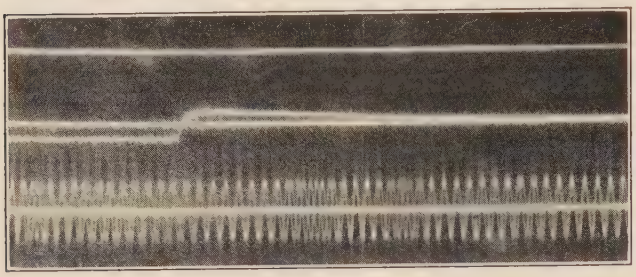


FIG. 1

known during the World War welding activity, the method of resistance or reactance control in the design of machines, to limit a large impressed voltage, was abandoned and the pendulum swung to the other extreme. In this era were constructed machines incorporating no resistance and little reactance control. While these machines possessed an unusually high electrical efficiency, nevertheless the welding characteristics were highly undesirable; also, with this type of machine, welding in an overhead position was practically impossible except with fluxed electrodes.

It is now generally recognized that a satisfactory arc

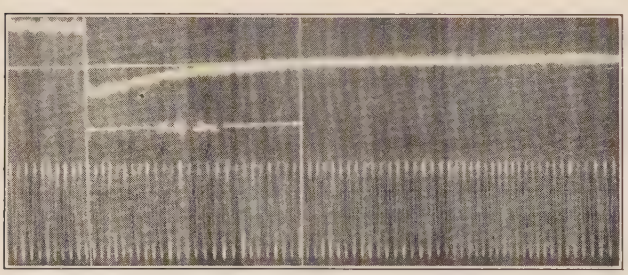


FIG. 2

welding machine will enable the operator to definitely control the arc; this results in smoother action and better welds. It is also recognized that the "speed of recovery" of a machine is a very important element. "Time of recovery" is defined as the time required for the return to normal welding conditions of voltage and current after the dead short circuit which occurs when the electrode is in actual contact with the work. This time has been cut down gradually from several seconds to a small fraction of a second.

The A. I. E. E. in its Standards for Arc Welding Apparatus gives a definition for time of recovery as follows:

"Time of Recovery.—The time required to assume conditions to within 5 per cent of their final value in an automatically regulated welding circuit after a definitely specified disturbance has taken place.

"The time of recovery of a welding generator is measured as follows: Insert resistance in the welding circuit of such value that normal full-load terminal voltage of the machine is registered across it at full-load current; short-circuit one-half of the resistance and allow conditions to become stable; then instantly remove the short circuit. The time required for the current and voltage to return to within 5 per cent of their original value is the time of recovery."

"Time of recovery" of a machine is a very important element; it has been gradually lessened until, under certain conditions, the recovery is instantaneous. The combination of suitable resistance and reactance control is necessary to produce the best welding conditions.

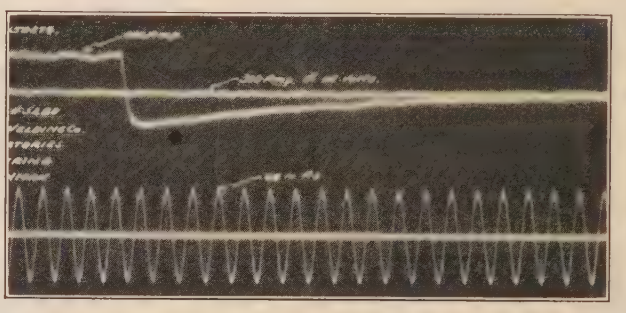


FIG. 3

All of the above facts are readily demonstrated with the aid of an oscillograph, and the author wishes to present a number of these portraying the gradual development of arc welding machines and the evolution from the old type of water-barrel resistance control to the modern arc welding apparatus.

The oscillogram in Fig. 1 is taken in connection with the early development of the resistance control machine. The timing of this curve as well as others is obtained by photographing a 60-cycle wave. Fig. 2 made during an interval of 0.433 seconds, is a reading from a recent generator which incorporates a modern type of reactance control. This is very good as far as it goes, but the problem of recovery is not solved. Reactance alone is conducive to very smooth welding but unfortunately hinders recovery. Resistance in the main circuit has little appreciable effect, but resistance introduced into the field circuit produces a quick recovery. At the same time, reactance inserted here appears, fortunately enough, to have little effect.

When compared to the time constant which indi-

cates the interaction of a series and shunt fields commonly known as transformer action, the time constant of the arc welding circuit is small. Improvement in time of recovery is noticeable in the Fig. 3. Of course to a certain extent the size of the generator also

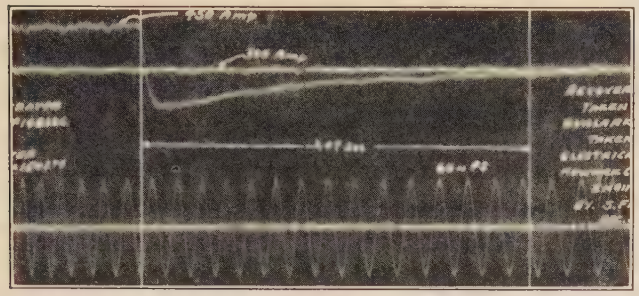


Fig. 4

determines this period of recovery, and obviously a small generator will recover more quickly than a large one. As an example of good recovery at 450 amperes, note Fig. 4 made during an average lapse of 0.247 sec. As a further example of recovery from 375 to



Fig. 5

300 amperes, note the next Fig. 5 indicating exactly 0.20 sec. This latter curve was produced by a motor-driven generator, rated at 300 amperes continuous duty and capable of supplying a welding current ranging from 40 to 400 amperes. That this type of genera-

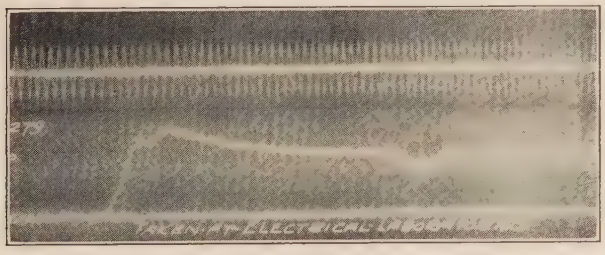


Fig. 6

tor produced favorable conditions under which to strike or start an arc on cold metal is indicated in the Fig. 6, which is an arc-striking curve; note the energy available almost at the instant of striking the arc. A current curve of about 300 amperes, taken during the process of welding on the same generator, is shown in Fig. 7. Fig. 8 is interesting, as it represents an attempt at welding on the part of an individual who never struck an arc before. Fig. 9 represents a corresponding voltage curve; while the curve is irregular. shows that the arc was never interrupted either by short-circuiting or by an open circuit.

On a smaller sized generator rated at 200 amperes continuous duty and with a welding range of 30 to 300 amperes, it is interesting to note that under work-

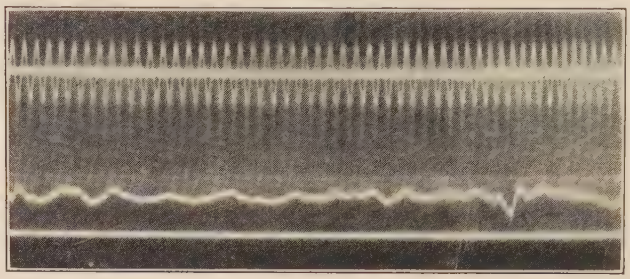


Fig. 7

ing conditions, the normal recovery is approximately 0.10 seconds (Fig. 9). Fig. 10 represents a 200-ampere continuous-duty machine with a welding range of 30 to 300 amperes, equipped with an arrangement obtaining constant flux in the field so that there is no overlap or hunting. A time of recovery of less than 0.01 seconds is indicated with this generator under normal working conditions.

This excellent curve has been produced by a machine which incorporates certain novel features to prevent the dying out of the field under short-circuit conditions.

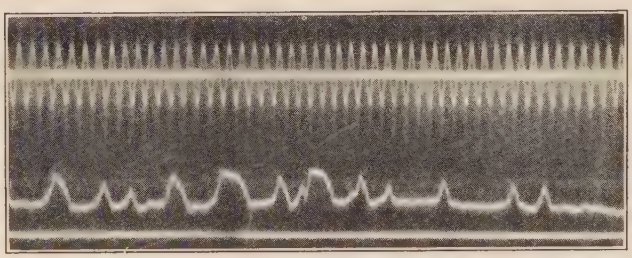


Fig. 8

Compared with the lag in time of recovery caused by the transformer action of the series and shunt fields, the ordinary time constant of a welding circuit is small; in fact by several means, the time lag can be practically overcome. The generator in question has a special voltage impressed on the field with an intervening reactance and a resistance to control the current; with this type of machine, the time of recovery is practically instantaneous, and voltages change from one value to another almost entirely without time lag.

The writer discovered that the time of recovery was largely dependent upon the changes in flux caused by reactions (one upon the other) of the changing currents in the shunt field, series field, and armature; and that if the field flux were held practically constant, the time of recovery could be controlled. There are

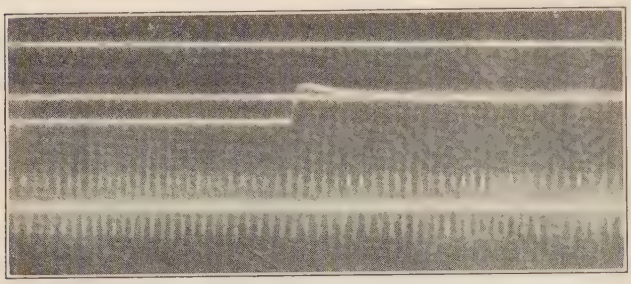


Fig. 9

several ways of doing this but one simple way is by means of an extra applied voltage.

This separate, additional voltage of the field may be impressed by either a separate exciter, a separate power supply, or a reactifier arrangement; for example, on a d-c. motor-generator it would be obtained from

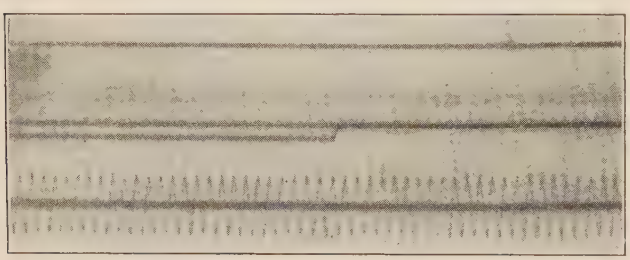


Fig. 10

the power supply; on an a-c. motor-generator, by means of rectifier tubes; and on a gas engine set, by means of an exciter. This separate voltage prevents the field from dying out and allows recovery to take place almost instantaneously.

The best recovery curves does not necessarily indi-

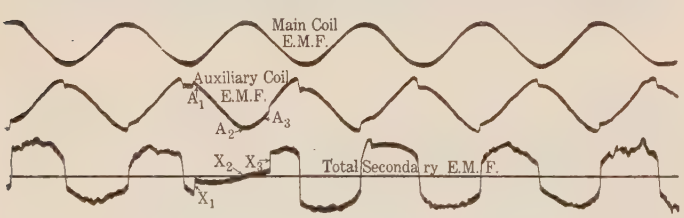


Fig. 11

cate the best welding conditions, but they do illustrate what is possible if a generator is arranged for a special setting, such, for example, as the welding of thin material or other production work. With a modern generator of this sort, it is possible to combine sufficient resistance and reactance to exercise a mutual dampening effect on either current or voltage, so that a 25-volt open circuit may be used to start an arc and maintain it. This is somewhat contradictory to the theory that a 60-volt open-circuit voltage is necessary to start the arc.

A great many of the phenomena which attends the striking and maintaining of an arc are stll unknown. In some ways, the arc produces an effect similar to a counter e. m. f. A thorough study should be undertaken of this subject.

In a-c. welding the time of recovery is much better than in direct current because for part of the voltage cycle, the a-c. arc tends to be extinguished. As a result of this, the a-c. curve is always smoother than the variations indicated by a similar curve representing the same quantity of energy obtained from a motor-generator set. This is brought out in Figs. 11 and 12

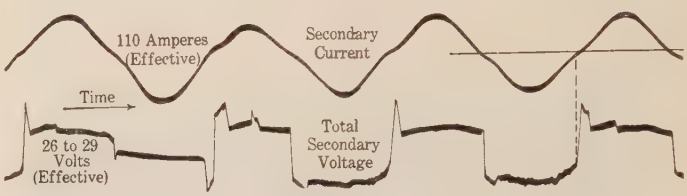


Fig. 12

which are taken in connection with an a-c. welding circuit.

The gradual evolution of welding machine design should be the result of a scientific study of the welding problem, and in this study, better welding conditions rather than increased electrical efficiency should be of first consideration.

WELDING FOR BUILDING STRUCTURES

The welding of building structures was discussed at the November 18 meeting of the New York Section of the American Welding Society. The revised code on welding building structures was presented, its chief differences from the former code being explained.

Andrew Vogel, of the General Electric Company, spoke on the progress of welding regulation; five cities have already adopted the code and 88 cities have adopted one that is similar in most respects. Europeans are using arc welding for building more than Americans, he said.

Gilbert D. Fish, of the Westinghouse Electric & Manufacturing Company, explained that the code goes beyond most codes in recommending workmanship and the importance of subjecting all operators to examinations.

A. M. Candy reported that four firms alone used welding in 91 buildings containing thousands of tons of steel and also used welding to reinforce fifteen bridges.

Abridgment of

Reading Suburban Electrification

Its Power Supply Facilities

BY C. L. DOUB*

Associate, A. I. E. E.

Synopsis.—*The Reading Company is now electrifying its Philadelphia suburban railroad service, planning it so that the electrification may readily be extended to include through passenger and freight service between Philadelphia and New York City, and Bethlehem and Reading, Pennsylvania. Contract has been made with Philadelphia Electric Company for initial power requirements, and provisions are made for enlarging such supply to serve all of the above enumerated territory.*

The Railroad Company is constructing substation and transmission facilities to serve the suburban territory by a 12/24/36-kv. three-wire, single-phase, 25-cycle distribution system, with the view to serving the more remote area by superimposing 66-kv. transmission lines upon the initial system, at the time of future extension. The present and proposed system layouts are described, together with the estimated power requirements and the manner in which the railroad system is to be served from the system of the power company.

THE present program of construction for electrification of Reading Company lines includes only suburban service in the vicinity of Philadelphia. This includes service to Lansdale, which is about 25 mi. along the Bethlehem Branch; to Langhorne, about 24 mi. along the New York Branch; to Hatboro, about 18 mi. along the New Hope Branch; and to Chestnut Hill, 10.8 mi. and Doylestown, 10 mi. from Lansdale and about 35 mi. from Reading Terminal.

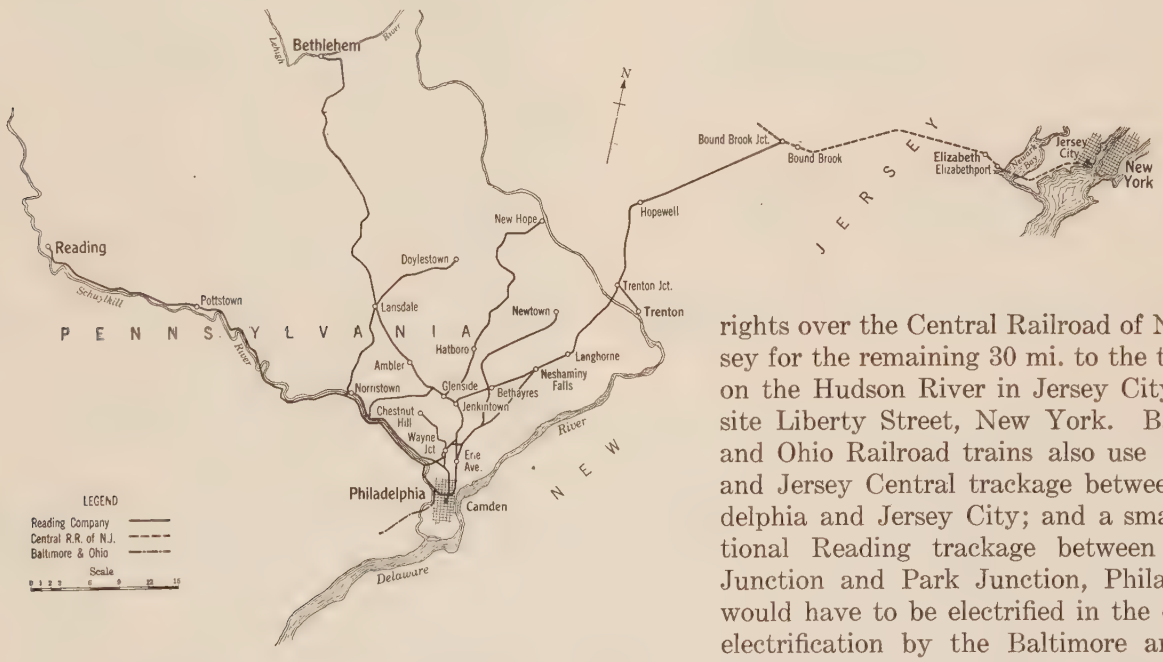


FIG. 1—PRINCIPAL READING COMPANY LINES IN TERRITORY FOR WHICH PLANS COVER POWER SUPPLY FROM PHILADELPHIA

SCOPE OF ELECTRIFICATION PLANS

All plans and designs, however, are made with a view to future extension for the electric operation of through passenger and freight service. The Reading Company has announced that these plans will eventually include electrification to New York City, Bethlehem (Pa.) and along the Schuylkill Valley to Reading (Pa.) or beyond. Fig. 1 shows the physical arrangement of these branches; electrification to New York involves Reading Company trackage only to Bound Brook, (60 mi. from Philadelphia) from which point this company has trackage rights over the Central Railroad of New Jersey for the remaining 30 mi. to the terminus on the Hudson River in Jersey City, opposite Liberty Street, New York. Baltimore and Ohio Railroad trains also use Reading and Jersey Central trackage between Philadelphia and Jersey City; and a small additional Reading trackage between Wayne Junction and Park Junction, Philadelphia, would have to be electrified in the event of electrification by the Baltimore and Ohio to New York. The present suburban program includes approximately 60 route mi. and 130 mi. of track electrified, including yards, sidings, etc. An addition of the prospective through passenger electrification includes approximately 140 route mi. and 380 track mi.; and further addition of freight electrification in the same area includes approximately 50 route mi. and 490 track mi.—making a total for all services of 250 route mi. and about 1000 track mi.

The Reading is well-known as a heavy freight railroad, its traffic density per mile of track ranking high with all roads in the United States. It will be neces-

*Assistant Engineer, Reading Company, Philadelphia, Pa.

Presented at the Middle Eastern District Meeting No. 2, of the A. I. E. E., Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

sary to provide for electrification of a large number of heavy freight trains including a considerable proportion of coal trains averaging 4200 trailing tons. The Reading passenger trains between Philadelphia and New York provide the highest type of passenger service and run consistently at speeds of 80 mi. an hour or greater. The New York trains are of medium tonnage, carry diners, chair cars, and club cars, but few sleeping cars on account of the relatively short distance. The Baltimore & Ohio trains using the same route include through equipment from the West and are of heavy weight. On the Bethlehem and Reading routes, the Reading provides through sleeping car service in conjunction with other railroads, and many of the passenger trains on these branches are of heavy weight.

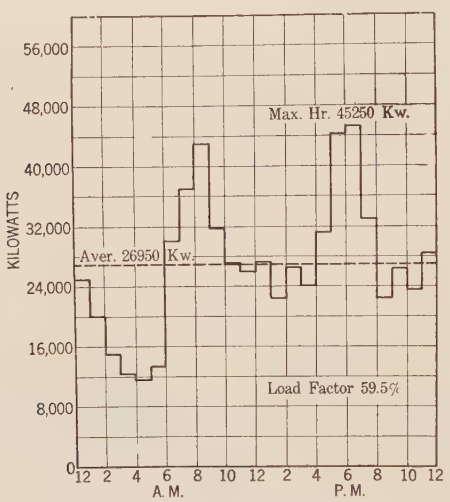


Fig. 2—Estimated Load Curve for Electrification Between Philadelphia and Bound Brook, Bethlehem, and Reading

Winter weekday traction load

All of the above, together with a heavy volume of Philadelphia suburban traffic and the addition of freight and passenger switching, etc., will include all forms of electric railroad service, and the power system is being designed with all of these conditions in mind.

Calculations show that present loads will be about 9000 kw. and 12,800 kv-a. average for maximum hour. Future loads on Reading trackage in the area which may be fed from Philadelphia will involve maximum hour loads of about 45,000 kw. and 65,000 kv-a. The load factor of the initial suburban service is typical of that of most large cities, and will be nearly 30 per cent. The addition of freight and through passenger trains, many of which are run throughout the night, raises the estimated load factor to about 60 per cent. The future load curve is shown by Fig. 2.

For the electrification of the Reading, the single-phase a-c. system was chosen, with nominally 11,000 volts on the overhead contact wires. The choice was based principally upon promoting system standardization in this territory and at the same time providing adequately for heavy freight and through passenger as well as suburban, traffic. Actual design is for 12,000 volts upon the trolley.

Main Point of Power Supply. It was early determined that in case of power being purchased, this should be at Wayne Junction, Philadelphia, which is the junction of several lines. This location is five miles from Reading Terminal where the general offices of the company are located together with division operating and dispatching headquarters. Studies and estimates were also made on the basis of the railroad company building and operating a generating station.

The result of studies and negotiations was that the Philadelphia Electric Company would provide at Wayne Junction a 60- to 25-cycle frequency changing station to be owned and operated by that company and to supply 26-cycle single-phase, power at 13,200 volts to the Reading Company at a single point. Early in 1930 a contract was signed providing for an initial load of 9200 kw. at a minimum (without penalty) of 65 per cent power factor and 30 per cent load factor. The rates were established for initial service on the customary basis of primary or demand charge to apply to monthly maximum demand in kilowatts, and secondary or energy charge to apply to actual kilowatt-hour consumed. The secondary charge is subject to correction based upon the actual cost of coal to the Philadelphia Electric Company and the actual cost of generation of hydroelectric power, properly weighed as to the proportion of steam and water power produced. The contract is for a term of 20 years and includes provision that when the railroad company loads shall reach a predetermined value in kilowatts and load factor (which would result only from through passenger and freight electrification) charges shall be determined upon a "cost plus" basis.

The Electric Company determined upon a frequency changer unit of 15,000 kw. at 70 per cent power factor as the proper unit for installation, and two such sets will be installed in the initial station. These sets will be for outdoor installation, and will be the first of such installations in the country.

The layouts of the Philadelphia Electric and the Reading Company facilities are both made so that the Wayne Junction supply may be enlarged to a total of six such units with a capacity of 90,000 kw. and 128,000 kv-a. The frequency changer station will be fed by 13,200-volt, 60-cycle, three-phase underground cables from the Westmoreland Station; duct lines with a total capacity of six 18,000-kv-a. circuits are being constructed between Westmoreland and Wayne Junction—a distance of about two miles. Independent cables will be run for each present and future frequency changer unit and will be fed from the duplicate 13,200-

volt, 60-cycle busses at Westmoreland Station. This station is the Philadelphia terminus of the transmission lines from the recently completed Conowingo hydro-electric generating station of the Philadelphia Electric Company, and in addition to being served by lines from Conowingo (via Plymouth Meeting Substation), is also served by 66,000-volt underground transmission lines direct from Richmond and Schuylkill Stations, and 13,200-volt underground lines from Delaware Station, all of which are steam generating stations of this company in Philadelphia. Moreover, the transmission lines from Conowingo tie at Plymouth Meeting Substation into the 220-kv. ring which interconnects the power systems of the Pennsylvania Power and Light Company and the Public Service Corporation of New Jersey with that of the Philadelphia Electric Company. (All of this have been described completely by Institute papers). It is thus apparent that the supply of power to the Wayne Junction Substation will be of the highest degree of reliability.

The Reading Company will construct its main substation adjacent to the frequency changer station, including transformers to step voltage up to the three-wire distribution system, and also step-up transformers for future transmission lines, together with a switching station for the trolley lines radiating from this station and headquarters for the power supervisor and load dispatchers. Cables will be run from each frequency changer set directly to generator breakers installed in the Reading Company Substation and then to the 13,200-volt 25-cycle bus provided by the Reading Company. This bus as temporarily installed will be made up of three sections, one transformer being fed from each, and the two frequency changer sets being connected to the two-end sections. The bus is designed to be ultimately a six-section ring bus, each section to have one 15,000-kw. generator (21,400-kv-a.) and two 8000-kv-a. step-up transformers. Adequate provisions are made for bus sectionalizing breakers together with current limiting reactors and reactor tie breakers. The bus will be installed initially as a single-phase bus, but provision is made to change this to a three-phase bus if it should be found that this is desirable for synchronizing purposes.

Provisions for Transmission Lines. The Reading Company load calculations show that the ultimate power supply can be transmitted adequately at a voltage of 66,000 volts, and provisions are being made for the extension of two single-phase 66-kv. lines each in the direction of New York, Bethlehem and Reading, and southward for possible interconnection with the Baltimore and Ohio Railroad.

The physical connections between the Baltimore and Ohio, the Reading, and the Central Railroad of New Jersey make it probable that it might be desired to interconnect the electrical systems of two or more of these railroads at the time of through passenger electrification of the Baltimore and Ohio or the Reading, and the 66-kv. transmission lines will permit the interchange of a suitable block of power between these systems. This power requirement may be for normal purposes to supply the combined loads in the most reliable and economical manner, or for emergency supply when there is deficiency of power from other normal connections. The layouts of the Philadelphia electric frequency changer station and the railroad company's main substation at Wayne Junction are both being made in such a way as to allow expansion for such purposes.

In addition to supplying power from Wayne Junction for the Reading Lines as far as Bound Brook, Bethlehem, and Reading, (which cover a radius of approximately 60 miles from Philadelphia) it may be feasible to purchase power at other points near the extremities of these branches. In this case, as desired, the 66-kv. transmission lines from Wayne Junction to such branches may or may not be run.

Three-Wire Distribution System. An early study of the economies and advantages of two- and three-wire

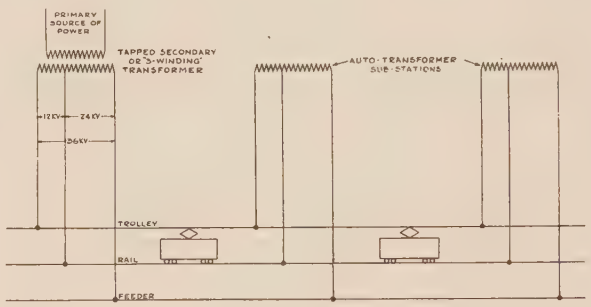


Fig. 3—Typical Three-Wire System Connections

(single-phase) transmission and distribution systems of various voltages led to the conclusion that the three-wire system with a voltage of 36 kv. between outside lines would have great flexibility for the Philadelphia area, would permit simple and frequent substations, and would be more economical in first cost and maintenance cost even though expanded in the future by 66-kv. transmission lines paralleling the three-wire system. This system of distribution is used by the New York, New Haven, and Hartford Railroad with 22 kv. between outside conductors and is used in a somewhat different arrangement by the Virginian Railway. Since the system is not altogether familiar to most engineers, the accompanying diagram (Fig. 3) will illustrate the typical connections. The trolley lines and rail connections are constructed in exactly the same manner as for the ordinary system. The operation of the third line, designated the "feeder," provides from the same single-phase transformer a potential between trolley and feeder of 36,000 volts which serves as a transmission line to outlying substations. Thus there is a voltage of

only 24 kv. between feeder and rail, and the insulation of the feeder conductors may be based upon this lower voltage.

Calculations and estimates show that for the Reading lines in the Philadelphia area the three-wire distribution system is very suitable for transmission within a radius of approximately 25 mi., but that it would not be economical and the voltage regulation would not be satisfactory for starting heavy trains beyond this radius. The addition of transmission lines to points beyond will therefore adequately care for the larger territory, and this territory may be served from one or more central points through similar three-wire distribution layouts fed from stations with step-down tapped-secondary transformers. The 66-kv. transmission line would thus become a very simple line between Wayne Junction and one outlying point on each branch, requiring the higher voltage circuit breakers at only the terminal points of the transmission lines. Manual or remote-control switching apparatus for sectionalizing and cross-tying the transmission lines at intermediate points may or may not be added, as desired; by installing tapped-secondary transformers instead of auto-transformers, and adding the required 66-kv. switching equipment, however, the flexibility of the layout will permit any or all substations along the route to be fed directly from the 66-kv. transmission lines. The most important stations at present are so laid out that by making very simple changes and additions to them, tapped-secondary transformers may replace the auto-transformers originally installed. This would occur only during some expansion of the electrification, at which time there would be need of additional auto-transformer capacity at other substations.

Circuit Breaker Protection. At an early date it was decided to use the high-speed type of circuit breaker in all trolley circuits. Very satisfactory high-speed circuit breakers had been developed for 11,000-volt trolley lines by two American electrical manufacturers, and both types of breaker had been in heavy duty service for a considerable length of time. One available type was an oil circuit breaker, and the other was an air type breaker, but both have high ratings and both perform very heavy rupturing duty for a number of duty cycles, many times that generally specified for normal speed oil circuit breakers. Both breakers demonstrated speeds of automatic tripping in from one-half to one cycle of a 25-cycle wave, and while mechanisms were radically different, results obtained were very similar. Their use decreased maintenance and frequency of inspection, minimized burning of trolley lines and equipment due to short circuits, and greatly reduced inductive effects from the railway system; but the cost of either type of available breaker was very much higher than for the corresponding normal speed circuit breaker.

The General Electric type JRA-32 air-break high-speed circuit breaker, with a rating of 1500 amperes continuously at 25 cycles, 15,000 volts, was selected for this service. It has an interrupting rating (single-pole) of 50,000 amperes at 12,000 volts, and is specified to perform 50 "OCO" duty cycles consecutively at two-minute intervals. Its principle of tripping on the short circuits is the so-called impulse tripping, depending upon the change of 25-cycle current from one-half cycle to the next. This scheme will be essentially the same as described in a paper by J. W. McNairy.[1] "Back-up" protection of high-speed impedance type relays is provided to take care of slowly increasing overloads and trolley-feeder faults.

Circuit breakers selected for feeder circuits are Westinghouse type GO-2, 46-kv., 800-ampere continuous rating at 25 cycles, and 500,000-kv-a. interrupting capacity (three-phase basis). They are provided with the recently developed "Deion Grid" break as described in a paper by Messrs. Baker and Wilcox presented before the Institute.[2] Although of the so-called normal speed type it is expected that the Deion grid type of break will give speeds of interruption materially faster than ordinary oil circuit breakers. A breaker of 46-kv. rating was chosen in order to provide a sufficiently high value of insulation to compare with line insulation used on these circuits, and also to provide ability to interrupt 36-kv. trolley-feeder faults.

Breakers selected for auto-transformers and trolley-feeder side of three-winding transformers at Wayne Junction are also type GO-2 of the same rating and design throughout, excepting that they are two-pole breakers. No breaker is installed in the rail connection to these transformers, this being tied solidly to the return bus which in turn is connected directly to rails, ground wires, etc.

Summary

The Reading Company's initial power supply is being obtained by purchase at one point from Philadelphia Electric Company. Power is metered at 13,200 volts, 25 cycles, single-phase, and is transformed by the railroad company to serve a 12000/24000/36000-volt three-wire single-phase, 25-cycle distribution system. Auto-transformer substations at various points step the 36-kv. voltage down to trolley voltage.

Future electrification will be served by expanding the present facilities without change, superimposing 66-kv. transmission lines upon the present system to serve the greater distances.

It is planned to receive power for testing of lines and trains, May 1, 1931, and to begin electric suburban operation in passenger service on July 1, 1931.

1. *High-Speed Circuit Breakers*, A. I. E. E. Quarterly Trans., October 1928, p. 1276.

2. *The Use of Oil in Arc Rupture*, A. I. E. E. Quarterly Trans., April 1930, p. 431.

ILLUMINATION ITEMS

Submitted by the Committee on Production and Application of Light.

THE LATEST STANDARD IN FOOTBALL ILLUMINATION

By H. G. Schiller*

The University of Detroit football field, on which evenly distributed illumination is produced from 320 kw. of electrical energy, is the latest illustration of this type of outdoor lighting. Its economical practicability



Fig. 1—University of Detroit Football Field

has been evidenced by a record crowd at each of the games played there.

The light on the playing area is adequate for the players to function as rapidly as by day and without

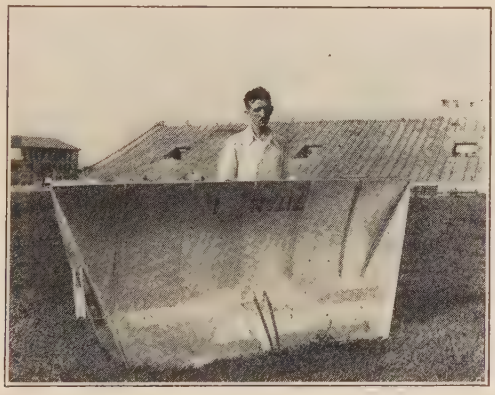


Fig. 2—Reflector used on Center Towers

annoyance from glare. Fig. 1 gives a general view of the field. The illumination is supplied by lighting units located on top of steel towers at each of the four corners of the field and on each side at the fifty-yard line. Each of the six towers is 105 ft. high, approximately 3½ ft. square, and is anchored with a concrete foundation, sunk approximately 5 ft. in the ground. The towers are so designed that they are capable of withstanding a 100-mi. gale.

The lighting equipment consists of two general types of units specially designed for this installation. The first type, Titan No. 1, is shown in Fig. 2. It is 8 ft. at the top, 6 ft. at the bottom, 16⅛ in. deep. It is made

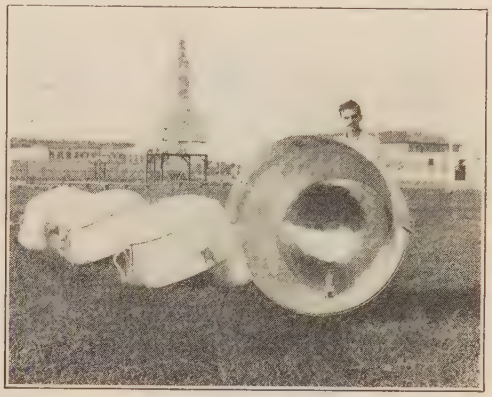


Fig. 3—Reflectors used on End Towers

of aluminum, the inside surface being oxidized. A chromium plated, copper-spun mirror reflects the light from the lamp and directs it onto the field. The reflection surface is supported by, and fastened to, an

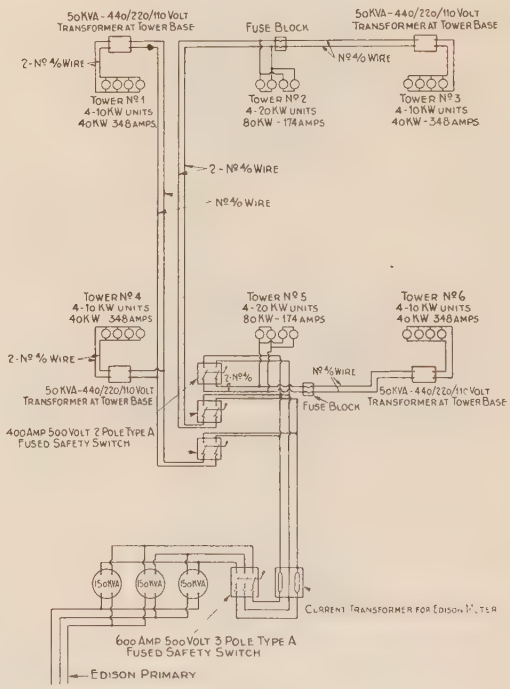


Fig. 4—Wiring Plan

exterior frame composed of structural steel members welded together into one unit.

The second type of unit, Titan No. 2, shown in Fig. 3 has a mouth width of 4 ft. and a depth of approximately 2 ft. It contains a 36-in. parabolic mirror, the reflecting surface of the surrounding housing of which is oxidized aluminum. The unit is substantially built—sheet

*Nela Park Engineering Dept., General Electric Co., Cleveland, Ohio.

aluminum is folded into shape over a structural steel frame and all the joints welded together, making it weatherproof.

On each of the central towers located on the 50-yd. line four Titan No. 1 units are mounted. In each of these are located with as close a spacing as possible, twenty 1000-watt MAZDA lamps. Two of these units are attached to a bar which in turn is secured to the inside top rail of the platform. In order to eliminate shadows, the lower units are not mounted directly beneath but are fastened in a like manner to a bar secured to the floor of the platform on the side facing the stand.

On each of the four end towers located opposite the goal cable. From the transformer at the tower base to the four 10-kw. units, the feeders are two two-wire 4/0 weatherproof cables per leg.

The east center and northeast towers are controlled together by one 400-ampere switch. The feeder from the switch to the center tower consists of two two-wire 4/0 parkway cables tied together at both ends. At the base of the tower a fused tap is made and one two-wire 4/0 parkway cable carries the energy to the north tower.

The west center and northwest towers are controlled together in identically the same manner as those above mentioned. Detail of additional wiring is given in the diagram.

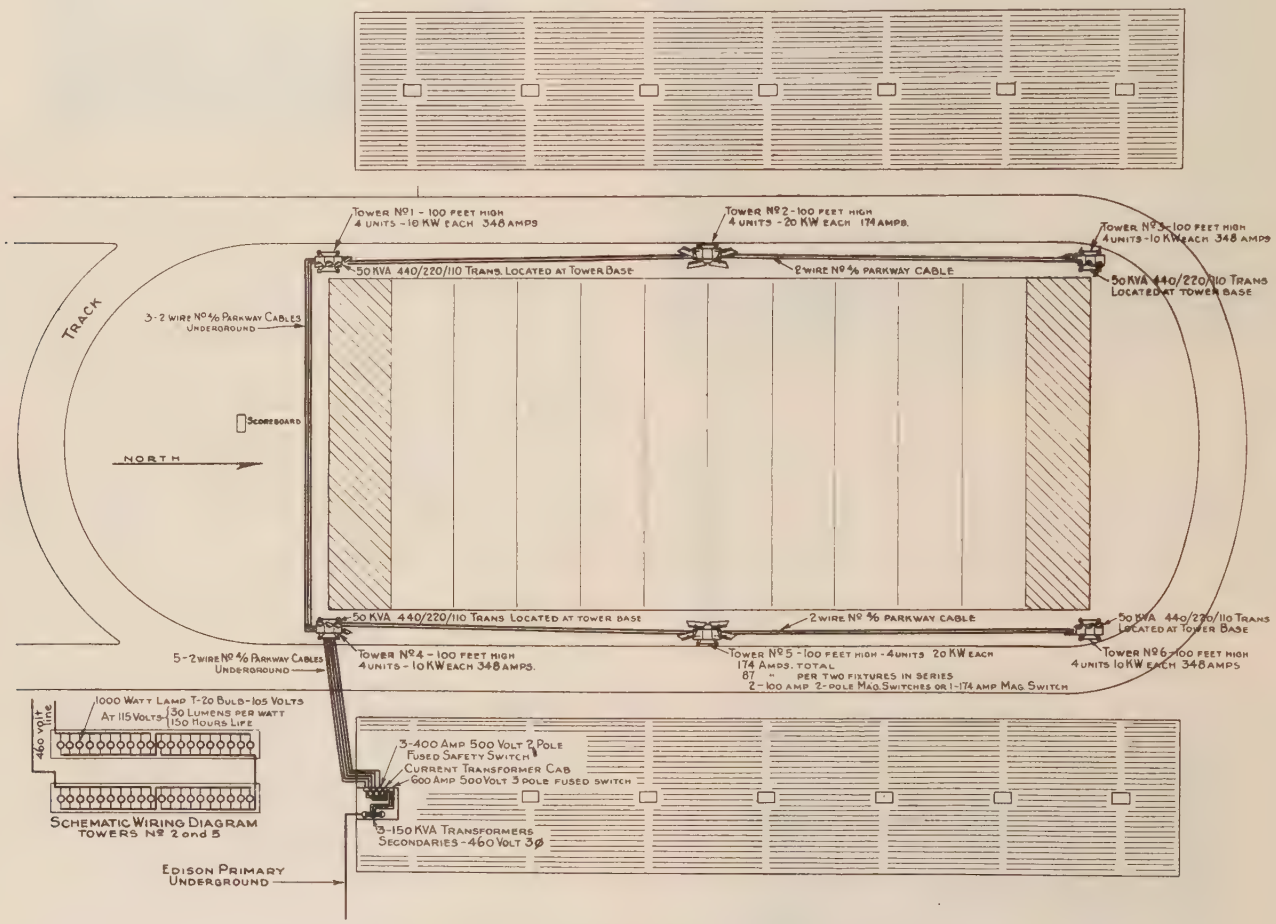


FIG. 5—WIRING PLAN

post are mounted four Titan No. 2 units, each equipped with a 10-kw. lamp. Three of these units are mounted on trunnion bases which in turn are fastened to a bar secured to the top rail of the platform; the other unit is fastened to a bar which is secured to the floor of the platform. (Fig. 1 shows the general arrangement.)

The system has a transmission voltage of 460, and an energy demand of 320 kw. (The general wiring lay-out is illustrated by Figs. 4 and 5.) The two south end towers are controlled together on a one-phase 400-ampere switch. The feeder from the switch to the transformer at base of towers is a two-wire 4/0 parkway

The entire system operates at an efficiency of 30 lumens per watt; the 10-kw. lamps operate at approximately normal life, while the 1000-watt lamps are burned 10 per cent over voltage, making the life of the entire system approximately 100 hr.—thereby facilitating maintenance, as theoretically all the lamps will need to be replaced at the same time.

The problem of maintenance has been given considerable forethought on the part of the designers; steel ladders running up the inside of the tower connect to a platform located directly beneath the units; by merely loosening a nut, the end units mounted on a

trunnion base may be swung around thus permitting easy access to the lamps; also, the top units on the center towers are easily accessible, the lower ones being so pivoted that they may be serviced without danger to the maintenance man.

The stands are lighted to an intensity of approximately 10 foot-candles by means of the regular field equipment. The Titan No. 1 unit has been so designed as to light both fields and stands, with the maximum intensity directed on the field.

The walks leading from the various entrances to the stadium proper are lighted to a satisfactory intensity by means of 200-watt lamps in 832 Holophane units spaced 30 ft. apart. This system is controlled separately from the field lighting.

Minor electrical troubles may momentarily drop the curtain of darkness over many a gathering of night football enthusiasts; but not so at this field. An auxiliary lighting system consisting of two 20-in. RLM domes per tower—each equipped with 1000-watt lamps—burns throughout the game; and being independent of the regular system, the possibility of darkness becomes an improbability eliminating the likelihood of petty thieving and perhaps rioting should the field and stands be suddenly plunged into darkness.

Credit for the design and installation of this outstanding step in illumination belongs to E. F. Labadie, Electrical Engineer of the Fisher Body Company, Detroit, and Harry Martin of Martin & Gibson Company, Detroit.

A NEW CARBON ARC LAMP FOR INDUSTRIAL APPLICATIONS

By W. C. Kalb*

A greater use of the carbon arc for the production of ultra violet radiation needed in many industrial irradiation processes has been made possible by the recent development of a powerful carbon arc lamp which has a long burning period and supplies radiation of constant intensity.

Irradiation of food products, stock, and poultry feed and other organic products is efficiently accomplished by means of this new carbon arc light. Paint and dye tests under this light check results obtained in tests under natural sunlight, with the advantages of much greater speed. Furthermore, the constant intensity of this carbon arc light insures greater accuracy in comparative tests than is possible to obtain under the varying intensity of natural sunlight. In processes using the chemical action of light as a drying agent, this new lamp is proving highly efficacious. It is especially well adapted to those processes requiring ultra violet radiation of greater intensity than has heretofore been available.

*National Carbon Company, Inc., Cleveland, Ohio.

A four-lamp unit designed for group irradiation in hospitals and sanatariums is shown in the accompanying illustration. These units are likewise adaptable to clubs, swimming pools, and the recently inaugurated ultra violet irradiation of industrial employees. One-, two-, three- and four-lamp solarium units are available for applications of this type.



Fig. 1—45-90 Ampere Carbon Arc Lamp

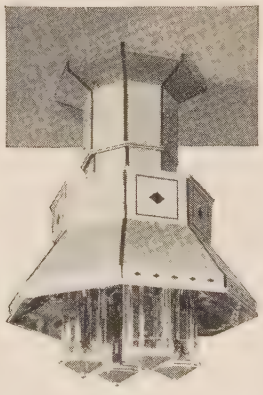


Fig. 2—Four-Lamp Solarium Unit

As may be seen by the illustration of the bare lamp, this new illumination unit is a dual-trim carbon arc lamp with motor-driven feed mechanism. The size of the lamp may be judged from the carbons, which are 12 in. long. Through automatic relays, constant-current arc control maintains uniform input of electrical energy at the arc and gives a steady light of constant

intensity throughout the period of operation. The arc burns between only one pair of carbons at a time. As these burn back, the arc shifts to the other pair without interruption, this shift occurring at intervals of approximately every half hour. One trim of carbons operating at 45 amperes arc current will burn continuously for twelve hours; at 60 amperes, the life will be ten hours, and at 90 amperes, eight hours.

Panels of ultra violet transmitting glass enclose the lamp confining the radiation from the arc to those rays found in natural sunlight. When short wave ultra violet radiation is required, these panels can easily be removed to permit operation with bare arc or replacement with quartz panels.

Equipped with cerium-cored sunshine carbons, and the special glass filter panels, this carbon arc light provides a close duplication of natural sunlight over the entire spectrum. At 60-ampere arc current it produces a light of 30,000 cp. with an intensity of ultra violet radiation equal to that of average sunlight at a radius of six feet. Four of these lamps supply a volume of illumination equal to that of the powerful carbon arc searchlight used on the Lindbergh Beacon, the clear weather visibility of which is limited only by the curvature of the earth and possible flying height. Using "C" carbons, cored with a composition of iron, nickel and aluminum, this lamp becomes a very powerful generator of ultra violet radiation, producing a light much richer in ultra violet than natural sunlight.

The lamp can be supplied for operation on either d-c. or a-c. circuit at 110 or 220 volts. The arc current can be adjusted to any value between 45 and 90 amperes.

This powerful source of illumination of constant intensity makes possible the application of light to industrial processes which, due to the uncertainty and varying intensity of natural sunlight, have in the past been impracticable.

BLOWING OUT THE LIGHT

Under the above caption, the I. E. S. *Transactions* for October describes a new device called "breath relay," which consists of special contacts mounted in a small tube with a mouthpiece like that of a telephone, and is so designed that it responds only to a puff of air. Speaking into it, shaking it, or striking it has no effect.

Its serious purpose is to provide a switch that can be operated without the use of either hands or feet, and it is expected to prove useful for safety devices of wide variety and for extending an operator's control of automobiles, airplanes, scientific apparatus, punch presses and other machines requiring the full use of the operator's hands and feet. A pianist or organist, for instance, would be able to turn the pages of his score without removing a hand from the keyboard or without other assistance.

PROGRESS IN AERONAUTIC RADIO RESEARCH

The development of radio aids to aviation is being forwarded through work of the National Bureau of Standards, which is operating also as the research division of the Aeronautics Branch, Department of Commerce. In recent months, improvements have been made in equipment for use with the system of radio range beacons which the department is installing on the airways. Since a beginning has been made in the installation of beacons of the type which operate a visual indicator, a greater need has been felt for an automatic volume control on the receiving set used aboard the airplanes. Such a device has been developed at the bureau. It relieves the pilot entirely of manipulation in the use of the visual indicator of the beacon signals. It can be used to advantage also in receiving aural-type beacon signals. Another application is in connection with the runway localizing beacon for use either at airports or as part of the system of blind-landing aids which is being developed at the bureau. In connection with the automatic volume control, a deflection instrument is used which serves as an approximate distance indicator. Recent experiments have also added a means of indicating when the airplane is directly over the beacon transmitter, so that the landing field location is thus conveniently and directly indicated to the pilot.

Another device developed at the bureau to facilitate the use of the visual-type range beacon is the "deviometer." (See *Technical News Bulletin* No. 162, p. 95; October, 1930.) By its use a pilot can follow any chosen course, within limits, on either side of the equi-signal line for which the beacon transmitter is adjusted. It is a shunting arrangement which varies the relative current in the coils actuating the two reeds of the reed indicator, and a pointer indicates the number of degrees off the equi-signal line for which the deviometer is set. The device has been found useful in experimental flight tests. The bureau recently furnished one to an air transport company for service tests.

As part of the aeronautical radio work at the bureau special attention has been devoted to receiving sets. For receiving both telephone messages and beacon signals aboard an airplane, receiving sets of special design must be employed. They must be so designed as to function under particular conditions of vibration, local interference, small input voltage, high output level required, and special audio-frequency requirements. The basic designs for such sets have been developed at the bureau. It also keeps in touch with commercial developments in aircraft radio receivers by means of laboratory measurements and experimental trials on an airplane. Satisfactory receiving sets are now found to be available commercially.—*Technical News Bulletin*, Bureau of Standards.

INSTITUTE AND RELATED ACTIVITIES

A. I. E. E. Winter Convention
January 26-30, 1931

A PROGRAM OF TIMELY TECHNICAL SUBJECTS AND ENJOYABLE ENTERTAINMENT

One of the most extensive technical programs on active engineering subjects advancing the theory and practise of the electrical profession will be offered by the A. I. E. E. 1930 Winter Convention which will be held in New York, January 26-30.

Papers on telegraphy, transportation, inductive coordination, protective devices, power transmission, industrial power applications, welding, research, and electrical machinery will be presented in eleven technical sessions representing the active progress of modern engineering.

Other attractive features to make this convention most enjoyable will be the Smoker (with special entertainment), the Edison Medal presentation and lecture, timely inspection trips, and the dinner dance.

Under the chairmanship of Mrs. E. B. Meyer a special program for the ladies will be arranged by the Ladies Entertainment Committee.

Special railroad rates on the certificate plan will be possible; by this means, the cost of the round trip will be reduced to only one and a half times the single fare. In order to obtain this special rate, everyone intending to embrace the opportunities and advantages which the convention will make available should secure a certificate from his local ticket agent, planning the return trip with the same routing as used in coming to the convention. Information regarding certain other specific regulations controlling the situation should be obtained from local ticket agents.

The schedule of events, tentatively arranged, is as follows:

TENTATIVE PROGRAM OF WINTER CONVENTION

MONDAY, JANUARY 26

10:00 a. m.	Registration
2:00 p. m.	A—Symposium on Telegraphy
8:15 p. m.	B—Joint Session of Committee on Transportation and the Transportation Group of the New York Section

TUESDAY, JANUARY 27

10:00 a. m.	C—Symposium on Inductive Coordination
2:00 p. m.	D—Session on Protective Devices
8:00 p. m.	Smoker, with special Entertainment

WEDNESDAY, JANUARY 28

10:00 a. m.	E—Session on Power Transmission
2:00 p. m.	Inspection Trips Board of Directors' Meeting
8:30 p. m.	Edison Medal Presentation and Lecture

THURSDAY, JANUARY 29

10:00 a. m.	F—Industrial Powers Applications
2:00 p. m.	Technical Sessions G and H G—Transportation H—Session on Welding
7:00 p. m.	Dinner Dance

FRIDAY, JANUARY 30

10:00 a. m.	I—Research
2:00 p. m.	J—Session on Electrical Machinery

A—SYMPOSIUM ON TELEGRAPHY

January 26—2:00 p. m.

Telegraph Transmission Testing Machines, F. B. Bramhall, Western Union Telegraph Co.

A Printing Telegraph Concentrator, W. B. Blanton, Western Union Telegraph Co.

Submarine Cable Telegraphy Influence of Interference, J. W. Milnor, Western Union Telegraph Co.

The Newfoundland Azores High-Speed Duplex Cable, J. W. Milnor, C. H. Cramer, W. D. Cannon and J. A. Randall, Western Union Telegraph Co.

Modern Practise in Private Wire Telegraph Service, R. E. Pierce, American Telephone and Telegraph Co.

B—JOINT SESSION OF COMMITTEE ON TRANSPORTATION AND THE TRANSPORTATION GROUP OF THE NEW YORK SECTION

January 26—8:15 a. m.

C—SYMPOSIUM ON INDUCTIVE COORDINATION

January 27—10:00 a. m.

Status of Joint Development and Research on Noise Frequency Induction, O. B. Blackwell, American Telephone and Telegraph Co., and H. L. Wills, Georgia Power Co.

Status of Joint Development and Research on Low-Frequency Induction, R. N. Conwell, Public Service Electric & Gas Co., and H. S. Warren, American Telephone and Telegraph Co.

Status of Cooperative Work on Joint Use of Poles, J. C. Martin, Midwest Utilities Co., and H. L. Huber, American Telephone and Telegraph Co.

Trends in Telephone and Power Practise as Affecting Coordination, W. H. Harrison, American Telephone and Telegraph Co., and A. E. Silver, Electric Bond and Share Co.

D—SESSION ON PROTECTIVE DEVICES

January 27—2:00 p. m.

Trend in Development of Modern Circuit Interrupters, J. B. MacNeill, Westinghouse Electric & Mfg. Co.

Philo 1930 Oil Circuit Breaker Tests; Aims, Set-up and Results from a System and Operating Point of View, Philip Sporn and H. P. St. Clair, American Gas and Electric Co.

Arc Extinction by Scavenging, D. C. Prince and W. F. Skeats, General Electric Co.

Field Tests on Standard and Oil Blast Explosion Chamber Oil Circuit Breakers, R. M. Spurck and H. E. Strang, General Electric Co.

The Trend of Development in Metal Enclosed Switching Equipment, M. H. Hobbs, Westinghouse Electric & Mfg. Co.

An Experimental Lightning Protector for Insulators, J. J. Torok, Westinghouse Electric & Mfg. Co.

Field Tests on Thyrite Lightning Arresters Using Artificial Lightning of 1,500,000 Volts, K. B. McEachron and E. J. Wade, General Electric Co.

E—SESSION ON POWER TRANSMISSION

January 28—10:00 a. m.

Traveling Waves on Transmission Systems, L. V. Bewley, General Electric Co.

Impulse Tests on Substations, A. S. Brookes and R. N. Southgate, Public Service Electric & Gas Co., and W. G. Roman and E. R. Whitehead, Westinghouse Electric & Mfg. Co.

Lightning Investigation on a Wood Pole Transmission Line, J. J. Torok, Westinghouse Electric & Mfg. Co., and R. R. Pittman, Arkansas Power and Light Co.

1929 Lightning Experience on the 132-Kv. Transmission Lines of the American Gas and Electric Company, Philip Sporn, American Gas and Electric Co.

Attenuation and Successive Reflections of Traveling Waves, James C. Dowell, General Electric Co.

F—Session on Industrial Power Applications

January 29—10:00 a. m.

Electron Tubes in Industry, W. R. King, General Electric Co.

Automatic Regulators in Industry, J. H. Ashbaugh, Westinghouse Electric & Mfg. Co.

Electrical Distribution Systems for Industrial Plants, W. J. McClain, Louis T. Klauder

The Synchronous Motor with Phase-Connected Damper Winding As a Drive for High-Torque Loads, M. A. Hyde, Jr., Westinghouse Electric & Mfg. Co.

The Design and Application of Synchronous Motors to Meet Special Requirements, D. W. McLenegan and A. G. Ferriss, General Electric Co.

Weather Making—A Public Service and a New User of Power, by D. C. Lindsay, Carrier Engineering Corp.

G—Sesssion on Transportation

January 29—2:00 p. m.

Inclined Catenary Calculations, B. M. Pickens, Westinghouse Electric & Mfg. Co.

Lackawanna Suburban Electrification, E. L. Moreland, Jackson and Moreland

Motive Power for Suburban Electrification, Charles Kerr, Jr., Westinghouse Electric & Mfg. Co.

The Transverse Fissure Detector Car, H. C. Drake, Sperry Products, Inc.

Design of Catenary System for Cleveland Union Terminal, N. F. Clement and E. E. Richards, Cleveland Union Terminals Co.

H—Session on Electric Welding

January 29—2:00 p. m.

Some Experiments with Arcs between Metal Electrodes, G. M. Shrum and H. G. Wiest, Jr., General Electric Co.

An Improved Arc Welding Generator, J. H. Blankenbuehler, Westinghouse Electric & Mfg. Co.

The Neutralized Welder and Its Applications, by F. Creedy, Lehigh University

A System for Direct-Current Arc Welding, by S. R. Bergman, General Electric Co.

Resistance Welding of Motor Frames, Malcolm Thomson, General Electric Co.

Electric Resistance Brazing, Samuel Martin, Jr., General Electric Co.

I—Session on Research

January 30—10:00 a. m.

Some Electrical Characteristics of Cable Oils, by H. H. Race, General Electric Co.

The Conductivity of Insulating Oils—II, J. B. Whitehead, Johns Hopkins University

Fundamental Properties of Impregnated Paper, J. B. Whitehead and W. B. Kouwenhoven, Johns Hopkins University

Traffic Control by Light Beams, R. C. Hitchcock, Westinghouse Electric & Mfg. Co.

Commutation and Current Collection in Hydrogen, R. M. Baker, Westinghouse Electric & Mfg. Co.

The Helical Groove, G. M. Little, Westinghouse Electric & Mfg. Co.

Studies in Non-Linear Circuits, C. G. Suits, General Electric Co.

J—Session on Electrical Machinery

January 30—2:00 p. m.

Mercury-Arc Rectifier Research, A. W. Hull and H. D. Brown, General Electric Co.

Effect of Transient Voltages on Power Transformer Design—III, K. K. Palueff, General Electric Co.

Stationary Flow of Heat in Large Turbine Generators, by C. Richard Soderberg, Westinghouse Electric & Mfg. Co.

Induction-Motor Slot Combinations, Gabriel Kron, Lincoln Electric Co.

The Pulling into Step of a Salient-Pole Synchronous Motor, H. E. Edgerton, Massachusetts Institute of Technology

Committees

The 1931 Winter Convention Committee is as follows: H. P. Charlesworth, Chairman; J. B. Bassett, C. R. Jones, H. A. Kidder, G. L. Knight, A. E. Knowlton, E. B. Meyer, C. E. Stephens and R. H. Tapscott.

The chairmen of the subcommittees are, respectively: J. B. Bassett, Convention Executive Committee; W. R. Smith, Inspection Trips; E. J. Johnson, Dinner-Dance; G. W. E. Draper, Smoker; and Mrs. E. B. Meyer, Ladies Entertainment.

Chicago Power Show Plans

"Meet the masters of power" is the slogan of the Fifth Midwest Engineering Conference, to be held at Chicago, February 10-15, inclusive, in conjunction with the Fourth National Fuel meeting of the A. S. M. E. and the Midwestern Power and Engineering Exposition. All engineers are invited.

Tuesday, February 10, there will be a Power Economies Session,—C. F. Hirshfeld, chairman—at which the following papers will be presented: *Balancing Plant Investment with Operating Cost*, by A. H. Kehoe, United Electric Light & Power Company, New York; *Advance in Electrical Distribution*, by H. W. Eales, Byllesby Engineering & Management Corporation, Chicago; and *Commercial Distribution of High-Pressure Steam*, by John M. Drabelle, of the Iowa Railway & Light Company. In the evening, another session, on Refrigeration and Ventilation will be held and the following papers presented, Alvin Baer of Frick Company, Chairman: *New Application of Refrigation in Air Conditioning*, by Willis H. Carrier, President of the Carrier Engineering Co., Newark, N. J. *Power Requirements in General Cold Storage Industry*, by George Horne, Merchants Refrigerating Company, New York. Wednesday's sessions also will be of special interest to electrical engineers, in the presentation of *Trends in Steam Turbine Development*, by A. H. Bailey of the Commonwealth Edison Company, (who will also act as Chairman); *Reciprocating Engines for the Higher Pressures; The Influence of Internal Combuston Engine Design on Practical Application*, by H. F. Shepherd, of the Cooper-Bessemer Corporation, Mount Vernon, Ohio; *Water Turbines of Propeller Type*, by L. F. Harza, of the Harza Engineering Company, Chicago. In the afternoon, with C. C. Whittier of R. W. Hunt Company of Chicago, Chairman, a luncheon session of papers will be presented including *High-Temperature Metals for the Power Plant*, by L. W. Spring, Crane Company, Chicago; R. F. Schuchardt, chairman of the afternoon session will present a dissertation on *Power Requirements for the Pumping of Oil, Gas and Gasoline; Electric Welding in the Power Plant*, by W. H. Zorn, Detroit Edison Company, *High-Voltage D-C. Transmission*, by C. W. Stone, General Electric Company, Schenectady. Other sessions will be on fuel conservation, prime movers, water problems of the power plant, and civil engineering. The exposition will be planned to demonstrate among other things how to reduce plant operating costs, the application of new methods to old plants, the betterment of production by the use of steam and electricity, with an important display in behalf

of engineering education and progress of the power engineer. Further details are available by addressing the C. E. Pfisterer, Secretary Midwestern Engineering Exposition, 308 W. Washington Street, Chicago.

The American Physical Society's Annual Meeting

In affiliation with Section B (Physics) of the American Association for the Advancement of Science, the thirty-second annual meeting of the American Physical Society will be held in Cleveland in the Physics Laboratories of the Case School of Applied Science and the Western Reserve University, December 30-31, inclusive.

Preliminary arrangements for the program include an address by the retiring vice-president of Section B of the A. A. A. S., Mr. F. K. Richtmyer, on Wednesday morning. In joint session with the American Physical Society, there will be presented a Symposium on Acoustics, Professor Paul R. Sabine, Doctor Harvey Fletcher and Doctor C. W. Hewlett all having been invited to present papers at this meeting.

AMERICAN ENGINEERING COUNCIL

ANNUAL MEETING DATE FIXED

The date of the annual meeting of the Assembly was fixed as January 15-17 inclusive. The meeting will take place at the Mayflower Hotel where the annual banquet will be held January 16, 1931.

TELEPHONE, TELEGRAPH AND CABLE REGULATION TO REMAIN WITH INTERSTATE COMMERCE COMMISSION

In a progress report opposing the Couzens Bill now pending in the Senate (for "the transmission of regulation of transmission of intelligence by wire or wireless")—Council's Committee on Communication declares that for the present at least, regulation of telephone, telegraph and cable common carriers should remain with the Interstate Commerce Commission. The committee is against the creation of an additional Federal regulatory commission except where existing agencies are not equipped to handle the work. It favors Federal regulation without depriving the states of their legitimate powers over interstate business, and believes that what is really needed is a reorganization of existing governmental bureaus, and legislation which will permit the unified operation of telephones, telegraphs, cables, and radio under governmental control.

The Committee on Communication is composed of Edwin F. Wendt (Washington, D. C.), Chairman; and O. H. Caldwell, (former member of the Federal Radio Commission), A. J. Hammond (of Chicago), Dean Dexter S. Kimball of Cornell University, C. B. Hawley (of Washington) and Frank A. Scott (of Cleveland).

COUNCIL URGES EARLY PUBLICATION OF U. S. G. S. DATA

During the two-day session, October 17-18, in Washington, D. C., the Administrative Board of American Engineering Council considered numerous committee reports and matters of concern to the engineering profession. A strong resolution supporting the action of the American Society of Civil Engineers in calling upon the United States Geological Survey for a prompt publication of water supply and other data secured by and through cooperation with the U. S. Geological Survey was adopted. The Board approved the program of the U. S. Coast and Geodetic Survey of the Department of Commerce, and requested appropriations for the purpose of extensive earthquake studies.

SINGLE COURT OF PATENT APPEALS

The report from the Patents Committee, Edwin J. Prindle, Chairman, was as follows:

"The chairman of the Patents Committee is attempting to bring into the movements for the Single Court of Patent Appeals, the other organizations which, with the American Engineering Council, have worked for the Patent Office and Patent System through the years. Accordingly, he proposed a resolution to the National Association of Manufacturers, advocating a Single Court of Patent Appeals, and authorizing its Patents Committee to represent that Association before the Committees of Congress in an effort to secure the required legislation.

"The National Association of Manufacturers unanimously passed the proposed resolution and your chairman proposes to draft a bill and submit it to the nine patent law associations throughout the United States. Their views will be secured and an effort made to obtain their endorsement."

FLOOD CONTROL REPORT

Upon the recommendation of Council's Flood Control Committee, resolution in part as follows was adopted:

"That this body adheres to the opinion heretofore expressed that so much is involved in the Mississippi River flood control project, that before final commitment to the major engineering features of the project is made, the Chief of Engineers of the Army should have the benefit of the counsel of the best hydraulic engineering talent that the nation affords. In its judgment some of the present expenditures, even though warranted as partial protection, may not be effective in the plan finally adopted."

The Council wishes to emphasize the fact that not only are engineering problems to be solved but economic problems as well. Investigation may show that the value of some tracts of lands does not justify large expenditures for flood protection, but that such lands should be taken over for reforestation under existing Federal laws.

COMPETITION BY GOVERNMENT ENGINEERS

Complaints have been continually received that some Federal Governmental agencies have engaged in or supported legislation which encouraged the practise of permitting government engineers in Federal employment to compete with engineers engaged in private practise. The Board authorized the appointment of a special committee to look into these cases and instructed the committee to render a report in January 1931.

BICENTENNIAL CELEBRATION OF BIRTH OF WASHINGTON

The Administrative Board endorsed the participation of engineers in the Bicentennial Celebration of the Birth of George Washington and instructed the executive secretary to prepare a suitable resolution upon this subject.

A New Course on Vibration Problems at Harvard University

Although well established in European, schools the importance of vibration in high-speed machinery has been neglected in most American engineering schools. Harvard University is now offering through its School of Engineering a new course on vibration problems, which is intended to acquaint its graduates with the physical and mathematical basis of mechanical vibration and literature available on the subject that they may be equipped to handle problems of increasing speed, size and power now developing in the engineering world. General direction of the course is under Professor Arthur E. Norton, of the School; the instructions will be given by outside lecturers, Messrs. J. Ormondroyd and A. L. Kimball.

Mr. Ormandroyd, who is a graduate of the University of Pennsylvania, (1920), is now manager of the Engineering Experimental Division of the South Philadelphia works of the

Westinghouse Electric & Mfg. Company, in addition to other duties, acting as a consultant to the Diesel Engine Department.

Mr. Kimball is an Amherst graduate; also a graduate of the Harvard School of Engineering (1914). After extensive engineering experience, he became Research Engineer to the General Electric Company in its Laboratory at Schenectady, where he is now Associate Head of the Mechanics Section. He has made special study of the photoelastic methods of stress analysis and is an authority on vibration damping. He has also contributed to scientific and engineering periodicals.

The course should appeal to progressive engineering school graduates who wish to supplement their basic education with a more intensive training.

Insulation Research Turns to Fundamentals

Of particular significance to those interested in the perfection of electrical insulation are two prominent trends of thought exhibited at the recent meeting of the Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council. On one hand, it is notable that there is a definite trend toward the concentration of study upon subjects designed to reveal basic fundamentals rather than to provide an immediate answer for any specific operating problem. On the other hand, the admission that there is an unbridged gap between the field of activity of the pure scientist and that of the applied scientist is an important fundamental step toward the bridging of this same gap to the ultimate benefit of all concerned. In the range of the technical program, physics, chemistry, and the specific subject of cable research came in for about equal treatment. It was announced that in response to repeated invitations from that organization, the 1931 meeting of the committee would be held at Harvard University.

Under the guiding hand of Doctor J. B. Whitehead, Johns-Hopkins University, the recent meeting was an unquestioned success both from the standpoint of attendance and the wide range of subjects discussed. It was held at the Bureau of Standards in Washington, D. C., November 7-8, 1930, and was the third annual gathering of its kind. Inspection trips through several of the laboratories of the Bureau of Standards provided an instructive break in the technical program, but because of the large amount of time consumed in the lively discussions at the technical sessions proved to be rather hurried affairs. Further details of this meeting will be published in the January issue of the JOURNAL.

A. I. E. E. National and District Prizes

The following National and District Prizes may be awarded each year:

National Prizes

1—FIRST PRIZES
Engineering Practise
Theory and Research
Public Relations and Education
2—PRIZE FOR INITIAL PAPER
3—PRIZE FOR BRANCH PAPER

1—The NATIONAL FIRST PRIZE in each of the three classes; namely, *Engineering Practise, Theory and Research*, and *Public Relations and Education*, consisting of $100.00 and a certificate, may be awarded to the author or authors of the best original paper presented at any National, District, or Section Meeting of the Institute.

2—The NATIONAL PRIZE FOR INITIAL PAPER, consisting of a certificate and $100.00 in cash, may be awarded to the author or authors of the most worthy paper presented at any National, District, or Section meeting of the Institute provided the author or authors have never previously presented a paper which has been accepted by the Meetings and Papers Committee.

3—The NATIONAL PRIZE FOR BRANCH PAPER consisting of a certificate and $100.00 in cash, may be awarded to the author or authors of the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, provided the author or authors are members of a Student Branch.

District Prizes

The following District Prizes may be awarded each year in each Geographical District of the Institute.

1—FIRST PRIZE
2—PRIZE FOR INITIAL PAPER
3—PRIZE FOR BRANCH PAPER

Each District Prize shall consist of a certificate of award issued by the officers of the Geographical District, and $25.00 in cash. It may be awarded only to an author or authors who are located within the District, and for a paper presented at a meeting held within or under the auspices of the District.

1—The DISTRICT FIRST PRIZE may be awarded for the best paper presented at a National, District or Section meeting.

2—The DISTRICT PRIZE FOR INITIAL PAPER may be awarded for the best paper presented at a National, District or Section meeting, the author or authors of which have never before presented a paper before a National, District or Section Meeting of the Institute.

3—The DISTRICT PRIZE FOR BRANCH PAPER may be awarded for the best paper based on undergraduate work presented at a Branch or other Student Meeting of the Institute, the author or authors of which are members of a Student Branch.

Attention is directed to the fact that the conditions require that all papers presented during the calendar year 1930 and to be offered in competition for the National Prizes, must be received in triplicate at National Headquarters in New York on or before February 15, 1931. These papers may be submitted by the author or authors, by an officer of the Institute, or by the executive committees of Sections or Geographical Districts.

Papers to be considered in competition for District Prizes should be submitted in duplicate by the authors or by the officers of the Branch, Section, or District concerned, to the District Committee on Awards, on or before January 10, 1931.

Any author or other member who is interested may obtain full information from the local Section or Branch officers, or by addressing Institute Headquarters, at New York.

Summary of Philadelphia Meeting Discussions

Only discussion given from the platform and submitted in writing in accordance with A. I. E. E. rules governing it is summarized. Complete discussion, together with all papers so approved, will be published in the TRANSACTIONS. A list of the papers presented was published in the September issue of the JOURNAL.

SESSION ON HYDROELECTRIC POWER

In discussion of *High-Speed, Low-Head Developments*, Mr. R. E. B. Sharp cited the two main advantages of Kaplan type turbines—higher part load efficiencies and increased power rendered. He believed the authors to be too conservative in their statement of approximate maximum horsepower value as limited by physical dimensions; he personally did not believe that for every case the increased earnings compensated more than amply for greater investment involved. The St. Lawrence River developments, with a large number of units and steady flow of small variation in head, are sighted as conditions where the increased investment would not be warranted.

In discussion of *Automatic Operator for Economy Control*, Mr. H. A. Von Eiff stated the results of studies made at the Holtwood plant. A large gain in economy resulted by operating one unit as a synchronous condenser on both the 25- and 60-cycle systems. When the load of the plant could be carried by one unit by operating another unit as a synchronous condenser which would be available for spare capacity, a saving of 150

to 300 cu. ft. sec., or a gain of approximately 500 to 1000 kw., would be effected.

Mr. C. F. Merriam discussed *Automatic Operator for Economy Control* bringing out several noteworthy points in addition to those in the paper. He called attention to the fact that although hydro units have approached the ultimate in maximum efficiency, they have not reached the limit in the economical use of water. Two interesting points were brought out by Mr. Merriam; one regarding the use of the ejector turbine, and the backwater suppressor during flood water conditions; and the other, the saving effected by securing a higher average head even though the pond is allowed to spill over a few tenths of a foot. Other interesting phases of operation of interconnected plants and combined steam-hydro plans were cited.

Mr. W. F. Skeats discussed the effect of *Damper Windings for Hydroelectric Generators* upon breaker duty. He agreed with the author that such a winding increases breaker current and decreases recovery voltage, but stated that as shown by a table of tests made on the system of the Northern States Power Company (with power supplied from their Riverside and Wissota Stations) more pronounced effect upon breaker operation is found in the case of three-phase short circuits.

Session on Electrical Equipment and Selected Subjects

Mr. W. W. Edson discussed *Outdoor Switching Equipment at Northwest Station* from the standpoint of relay operation when there are parallel lines with phases separately operated and not mechanically interlocked. He cited the possibility that a sensitive high-speed relay either in the ground residual circuit or in a cross-connection between the phases of the parallel lines might operate and improperly trip one or both lines.

Mr. C. M. Gilt discussed *A New System of Speed Control for A-C. Motors*, and gave a comparison of economic values of electric drives for induced draft fans. These costs were made in connection with a study to determine the most economical electrical methods of driving the induced-draft fans on the new boilers to be installed in the Hudson Avenue Station.

Mr. R. R. Sheely discussed *A New System of Speed Control for A-C. Motors* and asserted that the a-c. machine was the most undesirable unit of the system because slip-rings, operating continuously at voltages commonly used for power house auxiliaries, will require frequent inspection and cleaning. In conclusion he stated that the advantages to be gained from the simplified combustion control system when using the Rossman drive will overbalance the disadvantages arising from the introduction of complicated electrical machines.

Mr. Fraser Jeffrey, discussing Mr. Rossman's paper, demonstrated that variable speed is of prime importance to an intelligent selection of apparatus, and debated torque characteristics and proper sizes of the equipment for the Rossman drive.

Mr. R. A. Hentz inquired if the motor used could be of either synchronous or induction type, or what type was usually used? Mr. Rossman replied that the a-c. machine of the motor-generator set or the a-c. motor in the case of the drive unit may be of either type; further, he stated that all of the equipment purchased to date was of the induction type, but that some of the more recent studies involving large sized units are based on a-c. machines of the synchronous type.

Mr. L. F. Blume discussed *Transformers with Load-Ratio Control*, stating that the smaller control units described by Mr. Palme's paper under the heading of "Low Current Type" was developed at a reduced cost without sacrificing any of the features of the units used with large transformers. This result was made possible by simplification of the mechanical structure and accumulated knowledge of the performance of load-ratio control during the last five years in test and in the field.

Mr. J. S. Lennox discussed *Transformers with Load Ratio Control*, telling how important advantages in manufacture and installation have resulted from assembling the ratio adjusters and contactors in the manner described by this paper. He further stated that the sturdy construction, heavy contact pressures, and complete mechanical interlocking, (resulting in uniformly successful operation of the heavy-current equipment), have been retained in the smaller type.

Mr. W. W. Edson discussed this same paper from the operator's point of view, citing the need of careful mechanical design and accessibility for maintenance and repairs.

Mr. I. A. Terry discussed the effect of saturation on the *Forces in Turbine Generator Stator Windings*, analyzing the case of repulsive forces between the coil sides of a slot,—a point of interest in designing slot wedges.

Professor B. L. Robertson ably discussed this subject of *Forces in Turbine Generator Stator Windings*, calling attention to the fact that flux plotting or magnetic field plotting was resorted to throughout the paper. The importance of considering saturation as emphasized in the paper was counted noteworthy. In concluding Professor Robertson pointed out that the paper gives a start on further quantitative information concerning short-circuit forces on armature coils, and he believed that the results should lead also to better and more economical methods of coil bracing, spacing, and wedging.

Mr. L. A. Kilgore, discussing *Forces in Turbine Generator Stator Windings*, pointed out that because increased ratings and special designs now being considered will make demands on the bracing of end windings exceed the limits of any past experience, a thorough method of calculating these stator winding forces is very timely.

Session on Transmission

Mr. G. W. Lapp discussed *Electrical Porcelain* and complimented the author by saying that to a manufacturer of the product, the paper was a very human document; he further emphasized the statement in the paper that "a properly fitting glaze should increase the mechanical strength of the porcelain." The question "Why not glaze the insulator all over?" was raised, as were many other points regarding the process and manufacture of porcelain—such as firing, type of kilns, treatment of clay, etc.

Mr. Goodwin read a discussion of this same paper, prepared by Mr. Thomas and advocating the need of complete stress-strain curves for the various compositions of porcelain materials. The value of similar data in existence for metals was cited. It was the expressed opinion that advantages would result if porcelain could be reliably used in tension for insulating purposes.

Mr. K. A. Hawley, in his discussion of *Electric Porcelain*, pointed out the importance of glaze on performance of porcelain as emphasized by Mr. Kraner. He further stated that Mr. Kraner's paper should suggest to the transmission engineer that the constant improvements which are being made in high-voltage insulators may soon result in more efficient applications in service.

Professor Kouwenhoven inquired if Mr. Kraner could give data on the actual power factor of porcelain alone? He also gave an exposé of the conditions under which he had measured the power factor of porcelain insulators with the cap and pin cemented in place and found power factors ranging from 2.4 to 3.5 per cent.

Mr. R. J. Wiseman described the special features of manufacture, (handling, testing, and construction) of the *75-Kv. Submarine Cable for Deepwater Station.* The cable used on this installation was in the longest lengths of any 75-kv. cable ever made, and was the first extra high-voltage submarine cable.

Mr. D. C. Prince discussed *Magnitudes and Rates of Rise of Circuit Breaker Recovery Voltages.* He showed and described curves of tests made at Philo, Ohio, where it was possible to connect various lengths of transmission line to the circuit breakers under test and thus determine the effect.

Mr. A. O. Austin discussed *Lightning Protection from the Operating Company's Point of View.* He stated that the application of arresters to the line shows that there is some material

advantage for their use. Mr. Austin believes, however, that the cost of maintenance of arresters is out of proportion to the results obtained, and advocates applying the same cost to increasing the flashover voltage of the insulator strings by using wood arms and protecting the station apparatus by lightning arresters.

Mr. W. E. Lloyd discussed a number of points raised in Mr. Hansson's paper. He pointed out that the polarities of klydonograph records should be noted, and he believes also that the value of the ground wire can be evaluated and that it is a function of the ground and tower footing resistance, that ground resistance has been lowered by running radial streamers out into the ground from the tower legs.

Mr. W. W. Woodruff discussing lightning, resolved the subject in two general theories; one, direct strokes, and the other, induced strokes. From the installation of direct-stroke recorders the conclusion was that transmission lines do absorb a considerable number of direct strokes without their causing any trouble.

Mr. H. B. Vincent inquired of Mr. Hansson if after the addition of extra units, the insulator damage per individual string is greater or less than when the string contained fewer units?

Mr. L. F. Hickernell took exception to the statement in Mr. Hansson's paper that "ground wires are not only of no value, but are the cause of much trouble." Reference was made and data given from three annual reports of the N. E. L. A. Great Lakes Division which show that interruptions on lines without ground wires exceed by two to one those equipped with ground wires.

Professor Kouwenhoven explained that Mr. Hannson's paper was presented at a symposium held at the March 1930 meeting of the Institute's Baltimore Section. On previous occasions the section had the pleasure of hearing manufacturers representatives on the subject. Last March a meeting on lightning from the operator's point of view was held, and judging from present discussion the problem is still unsolved.

Session on Railway Electrification and Electric Traction

Mr. Sidney Withington discussed *Power Supply Facilities for Reading Surburban Electrification* and pointed out that a 30 per cent load factor is quite in line with that normally experienced in service. He emphasized the importance of Mr. Doub's reference to the desirability of interchangeability of electric motive power equipment among railroads and pointed out the need for standardization of equipment. He also discussed the important question of purchasing power as compared with the railroad itself producing it.

In discussing *Substations of the Broad Street Subway of Philadelphia*, Mr. Withington calls attention to the recent and rapid development of the rectifier for traction purposes, and pointed out the need for standardization of its rating.

In discussing *Utilization of Railroad Rights of Way*, Mr. Withington remarked the fine good spirit of the officers of both companies. Rental, responsibility, maintenance, and the transportation of energy were some of the other points which he discussed very ably.

Mr. Withington also discussed Mr. Griffith's paper *Initiation of an Electrification into Operation*, and explained the urge for immediately placing a railway electrification into service. He pointed out the desirability of locating the power director and train despatcher together if possible. The safety precautions and use of grounding sticks were discussed and the practise on the New Haven Road described.

Mr. C. E. Skinner discussed the paper by Messrs. Pritchard and Konn, and gave the historical development of the single-phase series commutator motor, referring to the work of Mr. B. G. Lamme and Mr. R. E. Hellmund. He described many of the recent refinements in design and construction.

The Louisville Meeting

An enjoyable four-day meeting of the Southern District was recently held at Louisville, Ky., from November 19th to 22nd. Over three hundred members, guests, and students were in attendance. Five technical sessions were held and interesting engineering papers were presented on the following subjects; electricity in the cement industry, welding, electrolysis, transportation, transmission and distribution, protective devices, and power generation.

Entertainment

The social features of the meeting consisted of an informal smoker with a lecture and demonstration held on Wednesday evening, and a dinner dance with entertainment held on Friday evening. Additional engagements, specially arranged for the ladies in attendance, consisted of a sightseeing tour of Louisville, a shopping tour, a matinee, and a bridge luncheon held at the Louisville Country Club.

Inspection Trips

Interesting inspection trips to unusual hydroelectric developments were taken by a number of the members in attendance. The Dix Dam, (which is the highest rock-filled dam in existence rising to a height of 275 ft.), and the modern Ohio Falls Hydroelectric Station equipped with miniature switchboard control, were visited.

Saturday was devoted entirely to trips of unusual historical interest and scenic splendor. The Lincoln Memorial, the house of Stephen Collins Forster at Bardstown, and Mammoth Cave, were also points of interest.

Addresses at Opening Session

The meeting was opened by E. D. Wood, Vice-Chairman, who introduced William D. Harrison, the Mayor of Louisville.

Mayor Harrison spoke of the present financial situation and welcomed all in attendance at the meeting to an enjoyable time at Louisville, notwithstanding existing financial depression.

Professor Rodman, Vice-President of the Southern District, presiding, introduced President W. S. Lee, who told of his trip through the western part of the United States and Canada in the interest of Institute activities. He explained the changes which are to take place in the Journal, and dwelt upon the importance of student activities.

Particularly was it his wish to be emphatic in urging the engineer to train himself to take part in the analytical management of business.

Mr. H. H. Henline, Assistant National Secretary, addressed the meeting in brief chronological delineation of the background of Institute activities, the establishment of sections and branches, and the holding of district meetings and national conventions. He concluded with an appeal for suggestions from the membership.

Professor Rodman closed the opening session, congratulating the Local Committee who had made such able arrangements for the meeting, and urging the members to attend the student session.

Students' Session and Conference

A student technical session in which were presented papers of high caliber was held on Thursday morning.

Considerable interest was manifested in a conference on Student Activities held on Thursday, following a luncheon given by the University of Louisville to faculty members and students attending the meeting. A more complete report of this conference and the student technical session will appear in the January issue of the Institute Journal. A summary of the discussions which took place at the technical sessions will also be given in a subsequent issue, a list of the papers presented having been published in the November issue of the Journal.

PERSONAL MENTION

EARLE S. HENNINGSEN has been appointed engineer of the A-C. Engineering Department of the General Electric Company, succeeding Mr. H. G. Reist, who has retired after forty-one years of exceptional service.

CHARLES E. BONINE has accepted the Directorship for engineering of the Benjamin Franklin Memorial and Franklin Institute Museum. He will continue, however, his interests and active association with the engineering firm of Bonine and Costa, in Philadelphia.

E. J. BLAKE announces the opening of a consulting office at 123 South Broad Street, Philadelphia, for the general practise of electrical and mechanical engineering, including investigation and development of regulating and control systems, new devices and processes, and manufactured products.

L. F. ADAMS, for the past three years chairman of the National Electrical Manufacturers Association's Standards Committee and Commercial Engineer of the General Electric Company, (with which he has been connected for over twenty years), has just been appointed chairman of the Casualty and Fire Protection Committee of the Association.

LEONARD J. NEUMAN, head of the Department of Electrical Engineering of the University of Santa Clara, and during the past two years Counselor of the Santa Clara Branch of the American Institute of Electrical Engineers, has accepted a position as Director of Geophysical Research for The Texas Company at Houston, Texas.

RUDOLPHO ORTENBLAD who recently became chief engineer for Pirelli S/A-Companhia Nacional de Conductores Electricos, Rio de Janeiro, Brazil, had been engaged since 1926 with the Rio de Janeiro Tramway Light and Power Company, Ltd., of the Brazilian Traction Company, where, until June of last year, he was Electrical Engineer.

T. C. RUHLING, formerly sales engineer for the Habirshaw Cable and Wire Corporation, has opened an office at 804 Burt Building, Dallas, Texas, where he will represent the I. T. E. Circuit Breaker Company, the Electric Power Equipment Corporation, the Pennsylvania Transformer Company, Philadelphia Electrical and Manufacturer, and others.

R. A. MCCARTY has been appointed manager of the Power Engineering Department of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, succeeding F. D. Newbury who advanced to general manager of machinery engineering. In the Engineering Department, Mr. McCarty has been associated with the design of industrial and power rotating apparatus, for three years prior to his present appointment being division engineer responsible for the design of large synchronous and induction types of rotating machines, excluding steam turbine-driven generators.

H. W. E. MOORE, engineering manager of the National Electrical Manufacturers Association activities for Westinghouse Electric & Mfg. Company, and recently appointed chairman of the Association's Standards Committee for the coming year, has just received the James H. McGraw Award, Manufacturers' Medal and Purse for 1930; presentation was made at the recent annual meeting of the Association, at Old Point Comfort. Mr. Moore has been with the Westinghouse Company since 1906. He is the Electrical Manufacturers Association's representative on several committees of the American Standards Association, the National Fire Protection Association, and other organizations.

Obituary

Edward John Stertman, power engineer of the Imperial Oil Refineries, Ltd., Montreal, Que., died suddenly October 22d. He was born in St. Louis, Mo., March 20, 1885, and for sixteen years served the Standards Oil Company of New Jersey and subsidiaries;—12 years as chief electrician; and for seven years in like capacity with the Imperial Oil Refiners Ltd., at Montreal. Mr. Stertman had been a member of the Institute since 1923, when he joined as an Associate.

C. H. Gaffeney, superintendent of telephones and telegraph, Central Railroad of New Jersey and Western Union Telegraph Company of New Jersey passed away at his home October 23d. He was born at Princeton, N. J., July 27, 1868; his high school education was followed by a term at the Trenton Normal School, the Trenton Business College, and a course in electrical engineering at Cooper Institute. After graduation from business college in 1886, he became telephone switchboard wire chief operator for the Pennsylvania Railroad Company at Jersey City, N. J., and in 1889, he was made manager of telephones and telegraph for the Adams Express Company, Jersey City. Three years later he took a similar position with the Pullman Company of Chicago. In 1894 he was made chief operator and dispatcher of the National Storage Railway Company, New York and Jersey City and in 1899 was engaged as chief clerk and assistant superintendent of the Central Railroad of New Jersey. Mr. Gaffeney had had broad experience in signal and electric light fields. In each undertaking his diligence and ability were marked. He joined the Institute in 1925.

Daniel Adamson, Member for Life of the Institute, and proprietor of Joseph Adamson & Co., Hyde, Cheshire, England, died October 11, 1930, two days after an operation. Born at Newton near Manchester, August 26, 1869, he was educated at a local private school; but he passed the Cambridge examinations held in Manchester about 1883. Subsequently, while serving an apprenticeship, he attended classes in electrical engineering and related subjects, at the Manchester Technical School and Owens College. The apprenticeship was of five years' duration, and thereafter for a short time he worked as supervisor for Messrs. Scott & Hodgson of Guide Bridge. Returning to his father's company, he performed various services as chief draftsman and in other capacities. Here his work included the office of managing supervisor of electrical engineering for electrical transmission, electric drives for traveling cranes and general distribution of power. Mr. Adamson joined the Institute in 1896.

Frederick P. Fish, of the law firm of Fish, Richardson & Neave, Boston, and a member of the Institute since 1902, (when he joined as an Associate), died at his home in Brookline, Massachusetts, November 6, 1930. Born at Taunton, Massachusetts, Mr. Fish was graduated from Harvard University in 1875, and from the Harvard Law School in 1878. For a while he practised law in Boston, and prior to his election in 1901 to the presidency of the American Bell Telephone Company, had established quite a reputation as a patent lawyer, arguing many important cases in the Federal courts for the Thomson-Houston Company, the New York Air Brakes Company and the Pullman Company. In 1907 he was succeeded as president by Theodore N. Vail, and returned to his law practise. For many years he acted as chairman of the Industrial Conference, pleading always for the open shop in American industry. Addressing an industrial group at the Waldorf-Astoria, he once asserted that "the right to strike" did not exist; in fact he endeavored to secure the passing of a law whereby general strikes would become illegal.

Mr. Fish served at various times as a member of the Harvard University Board of Overseers; he was a member of the Corporation and Executive Committee of the Massachusetts Institute of Technology and of the Council of Radcliffe College; chairman of the National Industrial Conference Board, and director of the

New England and Old Trust companies. He was a member of the American Academy of Arts and Sciences, of the Union, St. Botolph, Harvard, and Exchange clubs of Boston, and the Harvard and Bankers clubs of New York. His transfer to the grade of Member of the Institute took place in 1297. At the time of his death, he was seventy-five years of age.

Francis MacLehose, Superintendent of the Waterside Stations of the New York Edison Company, died November 17, after an extended illness. He was forty-six years of age. Born at East Orange, New Jersey, his preparatory education consisted of three years in the East Orange Schools, after which he entered as a senior at Stevens Preparatory School and was graduated in 1902. He then took the full four-year course at Stevens, from which he was graduated with a degree in Mechanical Engineering. Immediately he entered the employ with the New York Edison Company as substation operator, in which capacity he served until 1908, when he was promoted to central station operator. In 1910 he became assistant electrical foreman at the Waterside Station, was again promoted to system operator, and September 25, 1913, he was "loaned" as superintendent of the power house to Guild, Tennessee, for the Chattanooga & Tennessee River Power Company. He returned to New York two years later to assume the duties of assistant superintendent of the Waterside Station. Early in 1926 he became superintendent at Waterside Stations Nos. 1 and 2. Mr. MacLehose joined the Institute in 1907. He was also an active member of the American Society of Mechanical Engineers, the New York Electrical Society and others.

Ralph E. Thurston, for twenty-five years associated with the Connecticut Light and Power Company, at Putnam, Connecticut, and a prominent citizen and public official, died in the Fall River Hospital on October 6, following an operation. He was a native of Fall River, and after graduating from the local high school in 1897, he took a course at the Worcester Academy, from which he was graduated in 1898. In June 1902 he completed a course at Massachusetts Institute of Technology conferring a degree of B. S. in Electrical Engineering. After a term of service with the Chicago Edison Company as draftsman, and a short time as electric sign solicitor for the Narragansett Electric Lighting Company, he joined the Putnam Light & Power Company, (which has since become the Connecticut Light & Power Company) and was made its superintendent; at the time of his death, he was the company's manager. Mr. Thurston joined the Institute in 1905 as an Associate.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring prompt delivery of Institute mail. The accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work:

Bates, Putnam A., 117 W. 72nd St., New York.
Cole, C. M., 1814 Grove St., Berkeley, Calif.
Cromwell, R. C., 1814 Harris Trust Bldg., Chicago, Ill.
Ellenwood, Warren E., 1100 E. 177th St., New York, N. Y.
Gailun, Ben, P. O. Box 257, Angola, Ind.
Ghous, Shad G., P. O. Box 733, Schenectady, N. Y.
Gorrissen, Chas., Hermannstrasse 38, Hamburg, Germany
Grybek, John, 1575 Alice St., Oakland, Calif.
Holroyd, H. B., Dept. of Mech. Eng., Calif. Inst. of Tech., Pasadena, Calif.
Jones, D. Brainerd, 4306 45th St., Sunnyside, L. I., N. Y.
Keegan, W. G., 767 Maple Ave., Los Angeles, Calif.
Lieb, Adolph W., N. Y. Edison Co., 393 Seventh Ave., New York, N. Y.
Mahnke, E. Chris, 1400 E. 53rd St., Chicago, Ill.
McDougall, D. J., 1501 W. Pierce St., Phoenix, Ariz.
Pearson, Ernest, c/o Brewster, Farley Rd., Hartsdale, N. Y.
Schnake, H. C., 7 E. 42nd St., New York, N. Y.

A. I. E. E. Section Activities

FUTURE SECTION MEETINGS

Cleveland

December 18, 1930—*Decorative and Architectural Lighting*, by H. H. Magdsick, Executive Engineer, Engineering Dept., Nela Park; Retiring National President of the I. E. S. Joint meeting with Cleveland Chapter, Illuminating Engineering Society. Cafeteria lunch served by G. E. Lighting Institute.

January 22, 1931—*Future Power Development and Distribution in the Cleveland Metropolitan Area*, by H. L. Wallau, Chief Electrical Engineer, Cleveland Electric Illuminating Co.

Detroit-Ann Arbor

December 12, 1930—*Patents and Inventions*, by George N. Willitts, Secretary, Michigan Patent Law Association. Joint meeting with Michigan Patent Law Association at the Detroit Edison Auditorium.

January 20, 1931—*Underground Cables*, by G. B. McCabe, Detroit Edison Company, and L. F. Hickernell, Allied Engineers, Inc. Meeting at Detroit Edison Auditorium.

Lynn

December 3, 1930—*The Fishing Banks and Fishing*' by Bassett Jones, Consulting Engineer, Meyer, Strong & Jones, Inc. Ladies invited.

November 19, 1930—*Meters and Instruments.*
January 21, 1931—*Small Motors.*

Niagara Frontier

December 19, 1930—*Electric Furnaces in Manufacture of Carborundum and Abrasive Products*, with technical illustrated lecture from the Carborundum Company of America.

January 16, 1931—Dean Kimball, Cornell University, will speak on Industrial Economics or similar subject.

Seattle

December 23, 1930—*A Résumé of Recent Developments in Predetermination of System Performance*, by Dean H. V. Carpenter, of the College of Mechanic Arts and Engineering, State College of Washington.

January 20, 1931—Meeting on Communication Engineering by an engineer from the headquarters staff of the Bell Telephone Company.

Spokane

December—*Automatic Load Control*, by G. L. Lane. Joint meeting with the Northwest Scientific Society, which is preparing a program that will be announced later.

January 23, 1931—*Predetermination of Transient Stability*, by H. V. Carpenter, Dean, College of Mechanical Arts, State College of Washington.

PAST SECTION MEETINGS

Atlanta

Electricity in the Rubber Industry, by N. A. Nigosian, Goodyear Tire & Rubber Co. Three films, and samples of material were exhibited. Students from the Georgia School of Technology attended the meeting, preceded by a dinner. October 24. Attendance 56.

Baltimore

Adventures in Science, by E. L. Manning, General Electric Co. Joint meeting with the A. S. M. E. October 17. Attendance 113.

Boston

Inspection trip to the Woburn Substation of the Edison Electric Illuminating Co. of Boston, and Tewksbury Substation of the New England Power Association. October 4. Attendance 150.

Chicago

Power System Protection, by T. G. LeClair, Commonwealth Edison Co. Illustrated by slides. Joint meeting of the Power Group, Chicago Section, A. I. E. E., and Western Society of Engineers. October 23. Attendance 175.

Columbus

Some Phases of the Columbus Low-Voltage A-C. Network, by F. W. Marquette, Columbus Railway Pr. & Lt. Co. Inspection trip to the Pickaway Steam Plant was preceded by a talk by C. Z. Gillivan of the Columbus Railway Lt. & Pr. Co. October 24. Attendance 30.

Connecticut

Recent Developments at Safety Car, by Frank Godsey, L. B. Haddad, A. Bolsterli, and Mr. Van Ohlsen, all of the Safety Car Heating & Lighting Co. Meeting held at the above company in New Haven, preceded by a dinner. October 29. Attendance 100.

Dallas

Operation of Both the Surwell Gyroscopic Clinograph and Syfo-Clinograph, by M. T. Higgs and W. H. Emerson, both of the Sperry-Sun Well Surveying Co. Exhibits of this equipment on display. September 15. Attendance 113.

Observations of Power Plant Development in Germany, by G. W. Hamilton, Middle West Utilities System. Pictures taken by Mr. Hamilton of some of the more important power projects in Europe were used to illustrate the lecture. October 21. Attendance 116.

Denver

Heavy Electric Traction, by J. B. Cox, General Electric Co. Illustrated with lantern slides. Dinner preceded the meeting. October 10. Attendance 49.

Detroit-Ann Arbor

Modern Electric Elevators, by G. A. Mount, Otis Elevator Co. Illustrated. Considerable discussion followed in which a number of technical details were explained by J. Nicholson Barrett of the same company.

Erie

Transmission Design as Influenced by Field Studies of Lightning Phenomena, by Charles L. Fortescue, Westinghouse Electric & Mfg. Co. Dinner preceded the meeting. October 21. Attendance 80.

Fort Wayne

Theory and Application of Thyratron Tubes, by H. F. Droitcour, General Electric Co.;

Neutral Grounding Reactors for Power Systems, by E. H. Pemberton, General Electric Co. November 6. Attendance 75.

Houston

Make-up and Use of Alinement Charts, by Professor H. K. Humphrey, Rice Institute. C. D. Farman gave a report of the Summer Convention held in Toronto last June, and outlined some of the proposed changes in By-laws, JOURNAL, etc. October 21. Attendance 44.

Indianapolis-Lafayette

Modern Communication, by C. A. Breece, Indiana Bell Telephone Co. Illustrated with movietone pictures. Dinner preceded the meeting. October 24. Attendance 60.

Iowa

Development of Oil Circuit Breaker Design, by George W. Swallow, American Brown Boveri Co. Illustrated with moving pictures.

The Relation of the Institute and the University Student, by Professor F. E. Johnson, Iowa State College. C. L. Sampson, Chairman, outlined Section activities for the coming year, and described the Summer Convention held in Toronto last June. Talks by E. W. Schilling, Chairman, Membership Committee, and L. F. Wood, Chairman, Meetings and Papers Committee, on the proposed activities for this year. October 16. Attendance 36.

Lehigh Valley

Airport Lighting and Developments, by H. C. Ritchie, General Electric Co.;

World Power Conference, by J. A. Powell, W. S. Barstow Co., Inc. Illustrated with slides. Mr. Wolfinger, Pennsylvania Aeronautical Association, discussed briefly the present status of airports in Pennsylvania. Joint meeting with the A. S. M. E. held at the Berkshire Hotel in Reading. October 17. Attendance 124.

Los Angeles

Direct-Current Oil Well Drilling, by David Hall, Westinghouse Elec. & Mfg. Co. A discussion of the technical and economical point of view on this subject was presented by Glen H. Bowlus and Harry Hayes of the General Petroleum Co., A. H. Albrecht of the Standard Oil Co., and W. S. Johnson of the Union Oil Co. Mr. Simons, Bureau of Power & & Light, made a brief statement concerning the bond issue fostered by the city which was voted upon at the November election. October 14. Attendance 136.

Louisville

Off-Peak Method of Employing Electricity for Heating of Homes, by F. L. Townsend, Hall Electric Heating Co. October 16. Attendance 45.

Madison

The New Physics, by Professor Warren Weaver, University of Wisconsin. G. F. Tracy, Secretary, gave a report of the Summer Convention held in Toronto last June.

Memphis

Our Laws and Their Application, by W. D. Kyser, Memphis Power & Light Co. Annual Dinner. October 14. Attendance 46.

Milwaukee

Uses of Insulation for Domestic Purposes, by J. H. Bracken, The Celotex Co. Joint meeting with the Engineers Society of Milwaukee under the auspices of the American Society of Refrigerating Engineers. September 17. Attendance 100.

The Properties and Application Possibilities of Modern Organic Plastics, by L. V. Redman, The Bakelite Corp. Joint meeting with the Engineers Society of Milwaukee. Dinner preceded the meeting. October 15. Attendance 225.

The Single-Phase Condenser Motor and Its Application, by A. M. Forman, Louis Allis Co. Considerable discussion followed the presentation of this talk. November 5. Attendance 140.

Minnesota

Various Types of Electrical Control for Heat Regulation, by A. H. Lockrae, Minneapolis Honeywell Regulator Co. Mr. Taylor and Mr. Cunningham explained and demonstrated the various types of regulators manufactured by the above company. October 29. Attendance 32.

Niagara Frontier

Reminiscences of the Installation of Early Electrical Apparatus, by E. L. Doty, Westinghouse Elec. & Mfg. Co. Two reel film entitled "Dynamic America." Informal dinner in honor of the speaker held at the Hotel Niagara prior to the meeting. October 17. Attendance 70.

North Carolina

Mercury Arc Rectifiers, by O. K. Marti, American Brown Boveri Co., Inc. Illustrated.

Equipment for Changing Taps under Load, by C. L. Knotts, Westinghouse Elec. & Mfg. Co. Illustrated.

The Design of Large Steam Turbines, by J. G. Gidley, General Electric Co. Two sound pictures entitled "The Research Behind Sound Pictures" and "Finding His Voice" presented by S. A. Flemister, Southern Bell Telephone & Telegraph Co. October 21. Attendance 95.

Pittsburgh

The World Power Conference at Berlin, by C. L. Fortescue, J. B. MacNeill, and F. D. Newbury, all of the Westinghouse Elec. & Mfg. Co. Illustrated with lantern slides. Moving pictures followed. Joint meeting with the Engineers Society of Western Pennsylvania. October 14. Attendance 145.

Pittsfield

Sun-Spots, Radio, and the Weather, by Dr. Harlan T. Stetson, Director, Perkins Observatory, Ohio Wesleyan University. Illustrated with slides. Dinner preceded the lecture. November 4. Attendance 625.

Providence

Electricity—Past, Present, and Future, by Charles M. Ripley, General Electric Co. J. W. Young, Chairman, outlined plans for the coming year. Dinner in honor of the speaker preceded the meeting. October 14. Attendance 50.

Rochester

Recent Developments in Oscillographs, by Clare Anderson, Westinghouse Electric & Mfg. Co. Illustrated. Joint meeting with the Rochester Engineering Society and I. R. E. October 2. Attendance 89.

St. Louis

Getting the Public to Fly, by William B. Stout, Stout Air Lines, Inc. October 15. Attendance 75.

San Antonio

The Feedwater Problem of a Modern Steam Plant, by C. G. Krause, San Antonio Public Service Co.;

The Boiler Walls of the 1400-Lb. Pressure Boiler, by C. A. Maxwell, Fuller Lehigh Co.;

Interesting Features of the High-Pressure Turbine, by C. M. Duncan, Westinghouse Elec. & Mfg. Co.;

The Mechanical and Electrical Features of the Installation, by Frank Bell, United Engineers and Constructors;

Reasons for the High-Pressure Turbine Installation, by V. H. Braunig, San Antonio Public Service Co. Inspection of the new equipment in the high-pressure plant, followed by refreshments served by the San Antonio Public Service Co. October 27. Attendance 76.

San Francisco

Second World Power Conference, by Robert Sibley, University of California Alumni Association. The speaker described the general atmosphere of the World Power Conference, illustrating his talk with lantern slides and moving pictures taken during his ride of 1000 miles aboard the Graf Zeppelin as a guest of German engineers. He also described conditions in Russia, and explained how he gained admission there. The meeting was preceded by dinner at the Engineers Club. Joint meeting under the auspices of the A. S. M. E. October 23. Attendance 420.

Schenectady

Annual meeting for 1930. Executive business, followed by several reels of motion pictures of outdoor activities presented by C. E. Eveleth, General Electric Co. October 24. Attendance 160.

With Byrd in the Antarctic, by Russell D. Owen, *New York Times*. November 7. Attendance 450.

Seattle

Banquet followed by a varied program of entertainment. September 16. Attendance 109.

The Nature of the Electric Arc, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. Illustrated. October 2. Attendance 74.

Industrial Power Applications, by K. L. Howe, illustrated with lantern slides. Moving pictures showing the activities of the Puget Sound Power & Light Co. in supplying industrial power presented. Short talks by Messrs. Rockwell, Leihy, Quinan, and Onstad on various aspects of the above subject. October 21. Attendance 60.

Sharon

Grounding Banks of Transformers with Neutral Impedances, by F. J. Vogel, Westinghouse Elec. & Mfg. Co.;

Art in Industry, by D. R. Dohner, Westinghouse Elec. & Mfg. Co. Two reel film entitled "Dynamic America." October 13. Attendance 118.

The Electrical Industry and Electrical Engineering in Soviet Russia, by A. Dovjikov, Westinghouse Elec. & Mfg. Co. Motion picture entitled "Crystals of Commerce." November 4. Attendance 109.

Spokane

Automatic Operator for Economy Control Applied to Hydroelectric Generator Stations, by S. Logan Kerr, I. P. Morris and De La Vergne, Inc. Letter read from the Lincoln Electric Co. regarding prizes for papers on Arc Welding. October 24. Attendance 41.

Springfield

Electricity—Past, Present, and Future, by C. M. Ripley, General Electric Co. October 13. Attendance 28.

Toledo

H-Type Cable Joints, by A. J. Batchelor, Toledo Edison Co. Illustrated.

Japanese Power System, by Stephen Q. Hayes, Westinghouse Elec. & Mfg. Co. Illustrated with films showing maps, diagrams, and views of installations and scenes in Japan. October 17. Attendance 90.

Toronto

The meeting started with an inspection of the mechanical and electrical equipment of the Royal York Hotel, the Toronto Terminals Railway steam plant, and the Canadian Bank of Commerce. Following dinner, short speeches were made by J. J. Traill, Chairman, and R. J. Durley, General Secretary, Engineering Institute of Canada, and D. A. McKenzie, Chairman, Toronto Section, A. I. E. E. J. B. McAndrews, Welland Ship Canal, then presented a paper on the mechanical and electrical features of the Canal. L. J. Rundle also explained the electrical features of the Canal. Lantern slides were used to illustrate both talks. Joint meeting with the Ontario Section, A. S. M. E., and the Toronto Branch of the Engineering Institute of Canada. October 10. Attendance 160.

Operation of Dial Telephone System, by R. A. Fairbairn, Bell Telephone Co. of Canada. Illustrated by demonstrations and lantern slides. Moving pictures showing the operation of the dial system presented. October 24. Attendance 90.

Utah

Some Recent Advances in Radio Communication, by Prof. Thomas Parmley, University of Utah;

Telephonic National Broadcast Hookups, by Henry W. Oddie, Mountain States Tel. & Tel. Co. Reports of the Summer Convention at Toronto, and Pacific Coast Convention at Portland, by A. C. Kelm and H. T. Plumb. October 20. Attendance 37.

Worcester

Inspection of the new central dial system. October 22. Attendance 110.

A. I. E. E. Student Activities

PAST BRANCH MEETINGS

University of Akron

Executive Committee meeting. Harold H. Schroeder elected Secretary. October 6. Attendance 4.

University of Alabama

Two films entitled "Hydroelectric Power Production in the New South," and "Blasting the Water Highways of America." October 20. Attendance 45.

University of Arizona

Reports on A. I. E. E. Pacific Coast Convention held in Portland, by W. T. Brinton, Chairman, and Professor J. C. Clark, Counselor. September 19. Attendance 10.

Summer Experiences, by A. W. Fraps, Student. September 26. Attendance 10.

Summer Experiences, by F. J. Rietz, Student. Discussion of preliminary plans for electrical show. October 3. Attendance 10.

Inspiration Leaching Plant, by F. H. Henderson, Student. October 10. Attendance 9.

Film, "The Single Ridge." October 17. Attendance 9.

University of Arkansas

Talking Pictures, by Professor C. L. Farrar;

Vacuum Tubes, by Mr. Nelson, Student. Illustrated. October 22. Attendance 34.

Armour Institute of Technology

The Chicago Sanitary District, by J. T. Hawley, Chicago Sanitary District. October 20. Attendance 67.

Electrolysis in Telephone Cables, by R. G. Kellner, Student;

Prospecting for Metals by Electrical Methods, by T. S. Trzyua, Student. November 3. Attendance 49.

University of British Columbia

Television Transmission and Reception, by H. Wright, Student;

Manual Telephone Exchange, by J. Smith, Student. October 21. Attendance 13.

Recent Transformer Developments, by C. E. Sisson, Canadian General Electric Co., and Vice-President, District No. 10, A. I. E. E. Joint meeting with Vancouver Section. October 28. Attendance 60.

Polytechnic Institute of Brooklyn

Subway Lighting, by Ivan Block, Student. Committee appointments announced. October 16. Attendance 19.

Bucknell University

Professor W. K. Rhodes, Counselor, outlined the benefits of Student enrolment. October 8. Attendance 20.

California Institute of Technology

Election of officers as follows: Austin W. Strong, Chairman; George A. Ross, Vice-Chairman; John E. Girard, Secretary-Treasurer. Austin Strong, Chairman, and Professor R. W. Sorensen, Counselor, outlined the Pacific Coast Convention held in Portland in September. October 10. Attendance 14.

Application of D-C. Machinery to Oil Well Drilling Operations, by G. W. Hill, General Electric Co. Illustrated. October 22. Attendance 36.

University of California

History and Development of Power Plants, by C. E. Cherry, Student;

Airport and Airways Lighting, by W. P. Bear, Pacific Gas & Electric Co. Business meeting preceded the presentation of this paper. Joint meeting with the A. S. M. E. October 22. Attendance 35.

Inspection trip to the Pacific Gas & Electric Company's new Station A under construction in San Francisco. October 22. Attendance 39.

Inspection trip to two telephone exchanges of the Pacific Telephone & Telegraph Co. October 31. Attendance 21.

On the Air, presented by three A. S. M. E. Students. J. Spease, General Electric Co., outlined the General Electric Company's test course at Schenectady, and also told of the latest developments in the G. E. Laboratories. Illustrated with slides. Joint meeting with the A. S. M. E. November 5. Attendance 62.

Case School of Applied Science

Election of officers as follows: J. Arndt, Vice-President; R. H. Gardner, Treasurer; K. R. Spangenberg, Safety Representative. October 27. Attendance 25.

University of Cincinnati

Developments in the Electrical System of the Union Gas & Electric Co., by E. S. Fields, Union Gas & Electric Co. November 12. Attendance 48.

Clarkson College of Technology

Papers on summer experiences were presented by Professor A. R. Powers, Counselor, J. L. Stiles, Instructor, C. L. Brown and R. K. Fuller, Students. General discussion of Branch affairs followed. Committee reports presented. October 14. Attendance 32.

Fall Woods Dinner. October 18. Attendance 33.

P. Harney, Student, gave an account of his experiences as a detail draftsman in an airplane factory. O. D. Klitford, Student, outlined school work at Mechanics Institute, Rochester, N. Y. Professor A. R. Powers, Counselor, discussed the standing of the local Branch compared with other college Branches. October 28. Attendance 28.

Clemson College

The following papers were presented by Students;

Life of Faraday, by H. N. Fellers;

Electrical Heat Treating, by W. M. Barnwell;

Effects of Lightning Voltages on Rotating Machines, by J. H. Lewis;

Electrical Transportation, by L. T. Rogers;

Current Events, by G. B. Hagood. October 9. Attendance 41.

The following papers were presented by Students:

Life of Pupin, by G. C. Hoffman;

Electrical Communication, by W. A. Sanders;

Production and Application of Light, by C. A. Farrish;

Applications of Electricity to Iron & Steel Production, by H. S. Montgomery;

Current Events, by M. W. Caughman. Refreshments served. November 5. Attendance 41.

Colorado Agricultural College

Moving pictures showing the manufacture and application of electrical apparatus. October 16. Attendance 16.

Benton Colliflower, Clyde Butler, and Henry Wambolt, Students, gave short talks about the work which they did during the summer months. October 30. Attendance 11.

Experiences with the Westinghouse Electric & Mfg. Co., by Richard Crain. November 10. Attendance 18.

University of Colorado

Street Railway Organization and Management, by Nelson R. Love, Denver Tramway Co. October 22. Attendance 65.

Public Utilities, by H. B. Dwight, Colorado Public Utilities Commission. Refreshments served. November 5. Attendance 42.

Cooper Union

Election of officers as follows: Herman Grissler, President; August Dolle, Jr., Vice-President; August B. Mundel, Secretary; H. Laschiver, Treasurer. November 5. Attendance 6.

Cornell University

The Electrical Engineering Profession, by P. M. Lincoln, Director of the School of Electrical Engineering;

About the A. I. E. E., by Professor R. F. Chamberlain. October 10. Attendance 47.

University of Denver

Appointment of Membership Committee, and general discussion. September 24. Attendance 5.

Professor R. E. Nyswander, Counselor, outlined the advantages of Student enrolment. A report of the Membership Committee presented. Program Committee appointed. October 28. Attendance 18.

University of Detroit

Fundamentals of Radio Transmission, by E. H. Clark, Radio Station WMBC. Film, "Hidden Facts about G. E. Motors." October 23. Attendance 53.

Drexel Institute

Electrifying the Pennsylvania Railroad, by J. V. B. Duer, Pennsylvania Railroad Co. Illustrated with slides. Joint meeting with A. S. M. E. and A. S. C. E. November 4. Attendance 110.

University of Florida

The Installing of Sound Equipment in Theaters, by Professor Edward Smith. October 22. Attendance 30.

Georgia School of Technology

Two films entitled "The Steam Turbine," and "The Electric Ship." October 15. Attendance 243.

Harvard University

Type CN Automatic Network Relay, by P. R. Lincoln, Student;

Research Engineering, by R. H. Norris, Student. November 3. Attendance 17.

University of Idaho

General Discussion. September 22. Attendance 21.

Banquet and Get-together meeting. October 2. Attendance 42.

Practical Experiences in Electrical Engineering, by Professor R. H. Hull;

The Electric Arc, by Joseph Lancaster, Student. October 21. Attendance 31.

Moving pictures on the construction of cables presented. October 24. Attendance 51.

University of Iowa

Induction Furnaces, by C. Bartholow, Student;

Line Losses in Telephone Communication, by A. Behenke, Student. October 15. Attendance 36.

The Development of the Electric Railway, by L. F. Balluff, Student. October 22. Attendance 42.

Radio Telephone Service to Ships at Sea, by W. H. Carl, Student. October 29. Attendance 32.

Three motion pictures as follows: "King of the Rails," "Revelations," and "Beyond the Microscope." November 5. Attendance 38.

Kansas State College

Current Events, by W. S. Hemker, Student;

Some New Developments of the Electrical Power Field, by G. U. Combs, Student. Illustrated. E. F. Peterson, Student, gave an account of his summer experiences at Westinghouse Elec. & Mfg. Co. Afternoon session. October 2. Attendance 55.

Current Events, by Gerald Smith, Student;

Recent Developments and Inventions of the Westinghouse Elec. & Mfg. Co., by Mr. Kirby, Student. E. L. Ross, Student, related summer experiences while employed by the Westinghouse Elec. & Mfg. Co. Evening session. October 2. Attendance 55.

Current Events, by G. E. Cain, Student;

Summer Experiences with the General Electric Co., by H. R. Geiman, Student. Short talk by H. R. Dimmitt, Student. October 16. Attendance 104.

University of Kansas

Talks by three Students on their summer experiences. October 16. Attendance 38.

Lewis Institute

Lecture by D. A. Kennedy, Boeing School of Aviation at Oakland, Calif., explaining the teaching of aviation at the present time, and what is expected of graduates in aviation. Motion pictures were used to illustrate the lecture. November 7. Attendance 140.

University of Louisville

Films entitled "The Wizardry of Wireless," and "Liquid Air." John G. Lips, Chairman, outlined the changes in the By-laws concerning Student Enrolment, and William E. Bailey, Secretary, described the proposed changes in the A. I. E. E. JOURNAL. October 10. Attendance 33.

Massachusetts Institute of Technology

Electrical Communication, by O. W. Eshbach, American Tel. & Tel. Co. Illustrated. G. S. Brown, Chairman, outlined the benefits of Student enrolment. October 29. Attendance 310.

Non-Technical Talk on Recent Developments, by S. P. Grace, Bell Telephone Laboratories, Inc. Informal meeting at the invitation of the Engineering Societies of Boston. November 5. Attendance 45.

Michigan College of Mining and Technology

Walter Waisanen, Student, gave an illustrated lecture on the wiring system used in the new Electrical Engineering Laboratory. Brief talk by Frank Sawyer, Past-Chairman, outlining the activities of the Branch during last year. Professor W. H. Swenson, Counselor, gave a talk on the history, aims, and purposes of the Institute. October 7. Attendance 39.

Morse Gross, Student, told of his work in connection with the North Park Area Hydroelectric Power Project, and H. R. Reed, Student, outlined the 250,000-hp. hydroelectric plant being built on the Osage River. October 21. Attendance 27.

Michigan State College

Discussion of the social and political problems confronting young men, by Mr. Converse, City Attorney of Lansing. Short talks by R. Dearing, Chairman, Professors Cory, Foltz, and Murray, concerning the benefits of Student enrolment. October 15. Attendance 47.

University of Michigan

South America, by S. Q. Hayes, Westinghouse Elec. & Mfg. Co. Illustrated. October 16. Attendance 31.

Discussion of plans for future meetings. October 23. Attendance 16.

School of Engineering of Milwaukee

The Illumination Engineer's Place in the Utility, and Why the Utility should be and is Interested in Better Illumination, by I. L. Illing, Milwaukee Electric Railway & Light Co.;

Economic Aspects of Ventilation, by P. Rohrer, The King Co. October 22. Attendance 28.

Mississippi A. & M. College

General discussion of Branch affairs. Committees appointed. October 10. Attendance 36.

Talks on summer experiences by A. H. Peale, A. W. Peale, and K. M. Walcott, Students. November 4. Attendance 31.

Missouri School of Mines and Metallurgy

Stereoptic pictures of arc welding machines, and examples of its work, preceded by short business meeting. October 22. Attendance 28.

Montana State College

Report of the Pacific Coast Convention held in Portland, by Bruce Mull, Chairman. *Can a Lightning Proof Line be Built?* taken from the *Electric Journal*, presented by Norman Hovey, Student. October 16. Attendance 142.

Power from the Sea, taken from *Review of Reviews*, presented by George Read, Student;

Safety at Night for the Aviator, taken from the *Electric Journal*, presented by Ward Rightmire, Student;

Whose Job Is It? taken from the N. E. L. A. *Bulletin*, presented by Paul Koetitz, Student;

Hot-Sphere Anemometer, taken from the *Electric Journal*, presented by William Murrills, Student. October 23. Attendance 136.

Illuminated Ice at Lake Placid Club, taken from the *General Electric Review*, presented by Everett Blanchard, Student;

Electric Snow Melter, taken from the *Electric Journal*, presented by Edward Fisher, Student;

Industrial Trucks and Tractors, taken from the *Electric Journal*, presented by Edgar Dolum, Student;

New Trends in Mercury Arc Rectifier Developments, presented by Eric Blannin, Student. October 30. Attendance 46.

University of Nebraska

Film, "The Single Ridge." October 8. Attendance 25.

Summer work as meter testers, by Phil Ehrenhard, and Cyrus Hoekstra, Students. Work with the Northwestern Bell Telephone Co. as cable tester, by W. E. Stewart, Student. October 22. Attendance 30.

University of Nevada

Various Methods of Tone Control on the Modern Radio, by Clarence Jones, Student;

Servicing Radio Sets as a Summer Job, by Donald Knapp, Student. October 8. Attendance 17.

Newark College of Engineering

Condenser Motors, by J. S. Irving;

Electric Car Dumpers, by Mr. Olsta, Student. November 3. Attendance 31.

University of New Hampshire

Summer experiences with the Western Union outlined by Messrs. Potts and Moore. September 27. Attendance 37.

Short talks by Messrs. Moore and A. G. Pinkham, Students, on the multiplex tape system of telegraphing. October 4. Attendance 32.

Some Production Features of Induction Motors, by R. C. Croker, General Electric Co. Summer work with the Western Union outlined by Mr. Caldwell, Student. October 11. Attendance 29.

College of the City of New York

Making Light Audible and Sound Visible, by John B. Taylor, General Electric Co. October 16. Attendance 300.

Electric Welding, by John W. Gray, Westinghouse Elec. & Mfg. Co. Illustrated with slides. October 30. Attendance 25.

Two films entitled "Oil Films on Water," and "Hottest Flame in the World." November 6. Attendance 230.

New York University

Professor J. L. Arnold, Counselor, spoke briefly concerning the activities of the Branch in the past. Professor Brians of the Public Speaking Department explained several factors which directly influence the presentation of technical papers. October 1. Attendance 18.

J. Gegelys, Student, gave an account of his experiences with the N. Y. Edison Co. last summer, and described the kind of work he did in the testing laboratory. October 13. Attendance 18.

Impregnation of A-C. and D-C. Magnet and Field Coils, by J. B. McNally, Student;

Television Today, by P. Whiteman, Student. October 27. Attendance 18.

North Carolina State College

Construction of the Siegfried-Philadelphia 220-Kv. Single-Circuit Transmission Line, by A. W. Hamrick, Student;

Television, Its History, Practical Application, and Probable Future, by L. C. Vipond, Student;

Electrification of Ships, by C. D. Whaley, Student. October 20. Attendance 66.

Installation and Operation of a 66-Kv. Substation, by H. F. Lichty, Student. November 4. Attendance 50.

University of North Carolina

Professor J. E. Lear, Counselor, gave a talk on the aims and purposes of the Institute. *The Young Engineer*, by F. A. Jacobs, Student. October 14. Attendance 56.

Film, "The Single Ridge." November 6. Attendance 46.

University of North Dakota

Charles Breitwieser, Chairman, outlined the activities of the Branch for the coming year. September 18. Attendance 17.

Professor D. R. Jenkins gave a talk on his experiences during his leave of absence last year. Refreshments served. October 1. Attendance 37.

The Thyratron and Its Applications, by Charles Breitwieser, Chairman. October 29. Attendance 20.

Northeastern University

Linking the Past with the Future, by W. H. Colburn, Edison Electric Illuminating Co. of Boston. Illustrated. October 2. Attendance 49.

University of Notre Dame

Short-Wave Receivers and Adapters, by Mr. Caldwell, Kennedy Radio Corp.;

The Radio Compass, by Mr. Murray, Student;

Modern Methods of Brazing, by Mr. Lambert, Student;

The Life of Oerstad, by Mr. Andres, Student. October 20. Attendance 73.

Illumination, by David Tuck, Holophane Co., assisted by J. A. Toohey of the same company.

The Life of Coulomb, by Mr. Hawks, Student;

Ship to Shore Communication, by Mr. Harbough, Student;

The Comparison of Television with other Types of Electrical Communication, by John Anderson, Student. Patrick Murray, Student, presented the first engineering news digest of the year, and W. C. McCarthy, Student, gave a report of the trip to the Western Electric Co., recently made by several members of the senior class. November 3. Attendance 74.

Ohio Northern University

D. Pringle, Chairman, and Professor W. Krausnick, Counselor, gave reports of the District meeting held in Philadelphia in October. October 23. Attendance 24.

Corona Phenomena, by H. L. Hartman, Student. November 6. Attendance 30.

Ohio State University

Professor E. E. Dreese gave a short talk on the changes which are being made in the Engineering Curricula. Professor Lascher, Head of the Department of Journalism, gave a lecture concerning the trend toward educated instead of trained men in engineering fields. October 23. Attendance 32.

Smoker. November 6. Attendance 18.

Ohio University

Election of officers as follows: Harold Swigart, President; Russell Kelch, Vice-President; Herbert Adcock, Secretary-Treasurer. October 10. Attendance 10.

Film, "Blasting the Water Highways of America." October 29. Attendance 24.

Doctor Coolidge's X-Ray Tube, by A. L. Gregory, Student;

The Effect of Electric Shock, by George Rose, Student;

A. I. E. E. as an Organization for Electrical Engineering Students, by Professor A. A. Atkinson, Counselor. October 22. Attendance 28.

Electric and Heat Type Refrigerators, by Truman Wallace, Student;

My Summer Work with the General Electric Co., by Clinton Edgett, Student. November 5. Attendance 27.

Oklahoma A. & M. College

Two films "The Light of a Race," and "The Manufacturing of Mazda Lamps." Dean Donnell outlined his trip to the World Power Conference in Europe. October 9. Attendance 35.

The Exhaust Temperatures of Diesel Engines, by Dr. Maleev, Department of Mechanical Engineering. Meeting attended by A. S. M. E. students. October 23. Attendance 60.

Electrification of Railways, by Don Hefner, Student. Illustrated with slides. November 6. Attendance 15.

University of Oklahoma

Thrills of Power Plant Operation, by Elmer R. Pray, Student;

Power Transmission System of the Oklahoma Gas & Electric Co., by Professor C. T. Almquist. Professor F. G. Tappan, Counselor, explained the purposes and privileges of Student enrolment. October 23. Attendance 47.

Oregon State College

Radio Interference from Power Lines, by Professor F. O. McMillan, Counselor. October 30. Attendance 25.

University of Pennsylvania

Professor C. D. Fawcett, Counselor, gave a talk on Student enrolment. General discussion preceded the talk. October 31. Attendance 26.

Purdue University

Film, "Conowingo." General discussion of Branch affairs. October 30. Attendance 85.

Rensselaer Polytechnic Institute

F. M. Sebast, Counselor, gave a brief resume of the growth of the electrical engineering profession, and stressed the advantages of Student enrolment in the Institute. The following talks were then presented by Students:

C. R. Huntley Station of the Niagara-Hudson Power Co., by A. M. Lockie;

Assembly of Stromberg-Carlson Radios, by R. E. McAdam;

Operation of Station WTIC, by E. R. Sanders;

General Engineering Laboratory of General Electric Co., by H. T. Heaton;

Mercury Turbine at Hartford Electric Lt. & Pr. Co., by A. A. Pinto;

Cable Testing with New York Telephone Co., by L. F. Pries. October 14. Attendance 170.

Rhode Island State College

Talk by W. H. Anderson, Counselor, on the plans of the Providence Engineering Society exposition to be held in April. October 20. Attendance 9.

The Electrolytic Pail Forge, by L. Crandall and D. Williams, Students;

The Rescalescence of Iron Wire, by J. E. Schmidt and A. B. Porter, Students;

Spot Welding, by L. Crandall and D. Williams, Students. October 21. Attendance 17.

The Crystal Clock, by J. Murgo, Student;

The Photoelectric Cell, by L. Dumlowe, Student. November 3. Attendance 14.

Records supplied by the Bell Laboratories, Inc., outlining some recent developments presented. November 10. Attendance 8.

Rose Polytechnic Institute

Short talks by Messrs. Roach, White, and Dibble, Students, on Branch affairs. October 31. Attendance 40.

Rutgers University

Occurrences Due to Static Electricity, by L. P. Hoover, Head of the new Engineering Experimental Station. September 30. Attendance 20.

Principles of Arc Welding, by Mr. Shmurak, Student;

Applications of Arc Welding in the Laboratory, by Mr. Stanton, Student. The program for the coming year was announced. October 14. Attendance 15.

Santa Clara University

Power Transformers, by W. C. Smith, General Electric Co. Film, "Transformer Work in the G. E. Co." Joint meeting with the A. S. C. E. and A. I. M. E. October 8. Attendance 122.

University of South Carolina

Some Recent Expansions in Power Application, by C. H. Bryan, Student;

Truck Type Switch Gear, by E. L. Rankin, Student;

Illustrated Lecture on Locomotives, by H. L. Stokes, Student. October 10. Attendance 62.

Working with the New York Central Railroad, by S. O. Cowan, Student;

A Television Test at the General Electric Co., by F. H. Lucas, Student;

Instrument Transformers, by C. A. Riley, Student. October 13. Attendance 37.

Selecting D-C. Motors for Rapid Acceleration, by W. O. Farman, Student;

Measuring Inductance, by W. S. Smith, Student;

Work at the General Electric Plant, by F. H. Lucas, Student. October 20. Attendance 34.

Looking Into the Future, by G. N. Roberts, Student;

Some Details of Construction at the Saluda Dam, by A. R. Urghardt, Student. October 27. Attendance 33.

Short business meeting followed by film entitled "Building New York's Newest Subway." November 3. Attendance 10.

Today and Tomorrow in Electricity, by W. E. Crum, Student. November 10. Attendance 34.

South Dakota State School of Mines

Charles Laws, Chairman, outlined the privileges and advantages of Student enrolment. Short talks by Professors Clark and Kammerman on their experiences during summer work. October 7. Attendance 35.

University of Southern California

Talks on experiences while working in the test and construction departments of the San Joaquin Light and Power Corp., and Southern California Edison Company, given by J. R. Lutzenberg, C. L. Westmann, and H. S. Moody, Students. October 15. Attendance 37.

Modern Voltage Regulators, by O. A. Gustafson, General Electric Co. October 22. Attendance 29.

Swarthmore College

Two films, "Blasting the Water Highways of America," and "Building New York's Newest Subway." October 30. Attendance 41.

Induction Regulators, by Leon A. Rushmore, Student;

Operation of Induction Motors in Cascade, by Lewis Fussell, Jr. Student. November 3. Attendance 8.

Theory of Single Phase Motors, by Ralph M. Mitchell, Student;

Scherbius Method of Speed Control of Induction Motors, by Robert H. Lamey, Student. November 5. Attendance 7.

Syracuse University

The Panel Type Dial Telephone System, by Donald C. Robinson, Student;

The Step by Step Method of Telephoning, by Paul A. Greiner, Student. October 17. Attendance 25.

The Prosperity Garment Press, by George B. Smith, Student;

Installation Department of the Western Electric Co., by Howard F. Hamm, Student. October 24. Attendance 25.

Inspection trips to three transformer stations of the Syracuse Lighting Co. October 31. Attendance 25.

United States Army Signal Corps, by Ernest C. Wood, Student;

The Plant Division of the New York Telephone Co., by Donald R. Brown, Student. October 31. Attendance 25.

Inspection trip to the power developments on the Salmon River, November 5. Attendance 26.

Power Factor Meter, by Floyd J. Conklin, Student;

Mercury Arc Rectifier, by Edwin Hinchliffe, Student. November 7. Attendance 25.

University of Tennessee

Lightning and Its Effects, by J. E. Housley, Aluminum Co. of America;

The North-South Interconnection, by C. Hutchinson, Knoxville Pr. & Lt. Co. October 14. Attendance 41.

Texas A. & M. College

History of the Incandescent Lamp, by Jack Nahas, Student;

Manufacture of the Incandescent Lamp, by W. C. Keislivey, Student. October 13. Attendance 85.

University of Utah

Program for the coming year discussed and outlined. October 7. Attendance 14.

University of Vermont

High-Voltage Insulators, by A. L. Howard, Student;

Warren Telechron Method of Frequency Control, by M. L. Joslin, Student;

Fifteen Mile Falls Switching Yard, by L. Y. Spear, Student;

The Hydraulic Development at Fifteen Mile Falls, by P. H. Thomas, Student. These papers were presented after an inspection trip to the development at Fifteen Mile Falls. October 21. Attendance 27.

Crystal Control Clocks, by Austin L. Howard, Student. November 4. Attendance 25.

University of Virginia

W. S. Rodman, Counselor, outlined the purposes and aims of the A. I. E. E. October 6. Attendance 25.

Virginia Polytechnic Institute

Films on cable construction presented. October 23. Attendance 60.

Description of One of the City Power Plants of Richmond, by C. V. West, Student;

Making of Bakelite Products, by S. S. Brown, Student. November 6. Attendance 16.

State College of Washington

Professor O. E. Osborn, Counselor, outlined the purposes of the A. I. E. E., and also described his trip to the Summer Convention in Toronto last June. September 25. Attendance 40.

Deion Circuit Breakers, by Professor R. D. Sloan. Committee appointed to make plans for the Engineers' Show. October 8. Attendance 39.

Business meeting. November 5. Attendance 20.

University of Washington

Polarity in Electrical Discharge, by C. E. Magnusson, Director, Engineering Experiment Station. October 9. Attendance 22.

Radio Broadcasting, by James Wallace, Student. October 16. Attendance 17.

Colorado River Project, by F. E. Buckman, Student. October 23. Attendance 18.

Washington University

An Electron Tube Telemetering System, by A. S. Fitzgerald, presented by Paul E. Grivet, Student. October 16. Attendance 25.

West Virginia University

The following talks were presented by Students:

Importance of the Trolley Bus, by Mr. McMillan;

Page Ponce de Leon, by Mr. McCormack;

Brazing by the Resistance Method, by Mr. Wolfe;

Pennsylvania Railroad Electrification, by J. M. Morgan;

Thyratron Control Equipment for High Speed Resistance Welding, by Mr. Goddin. October 6. Attendance 32.

The following talks presented by Students:

Smoke Indicators, by Mr. Friend;

Trolley Bus, by Mr. De Lancy;

New Type of Ammeter, by Mr. Manion;

Controlling Army Pursuit Planes by Radio, by Mr. De Moss;

A Critical Analysis of the Lighting System, by Mr. Shaff;

Winding Coils for Armatures, by J. Kayuka. October 13. Attendance 32.

P. J. Johnson, Student, gave a report of his trip to the District meeting held in Philadelphia. October 20. Attendance 32.

Gas Electric Ditch Cleaners, by A. H. Goddin, Student;

Suspension Bridges, by H. V. Locker, Student. Two films entitled "Hydroelectric Power Production in the New South," and "Power." October 27. Attendance 30.

After some general discussion the following papers were presented by Students:

Future Trend in Ship Electrification, by C. J. McCormack;
The New Anti-Aircraft Guns, by S. B. Wolfe;
Staggering Brushes Lengthens Life of Commutators, by J. L. Simpson;
Span Across the Mississippi River, by J. M. Morgan;
Ultra Short Radio Waves, by A. L. Friend;
Railroad Electrification, by S. Boone;
The Earth as a Huge Generator, by C. B. Withers. November 3. Attendance 30.

The following talks were presented by Students:
Early Days in Transformers, by P. Shaff;
The Internal Combustion Engine An Adjunct to Railroad Electrification, by C. W. Thrall;
A Portable Emergency Local Distribution Substation, by C. F. Stewart;
Soldering Metal to Porcelain, by M. T. Sprigg;
Black Diamonds, by J. Kayuka;
Heat and Power from the Gulf Stream, by D. C. Kennedy;
New Process of Electric Welding, by C. H. Steenberger;
Industrial Trucks and Tractors, by W. C. McMillan;
Process of Making Steel Plate, by E. Hervey;
A Small Motor with a Large Starting Torque, by C. J. DeLancy;
Origin of Engineering Insignia, by B. T. Williams;
Process of Making Steel, by A. F. Fervier;
Oil Electric Engine, by G. Engle;
A New Transmission Line Construction, by J. E. Newcomer. November 10. Attendance 24.

University of Wisconsin

The Students attended the regular meeting of the Madison Section, at which Professor Warren Weaver presented his address, *The New Physics*. October 15. Attendance 90.

Worcester Polytechnic Institute

The Development of Underground Cables, by Professor F. J. Adams. Refreshments served. October 20. Attendance 38.

University of Wyoming

Business meeting. October 7. Attendance 13.

L. R. Probst, Mountain States Tel. & Tel. Co., gave a brief talk outlining the organization of the telephone companies in the United States, and mentioned some of the outstanding developments in the telephone field of engineering in recent years. Mr. Deuel, of the same company, gave a description and demonstration of the teletype machine. Joint meeting with the A. S. M. E. October 21. Attendance 35.

Yale University

The Square Hole for the Square Peg, by P. Thomson, Student;
General Induction into Efficiency, by R. M. Ferris, Student;
Wage Systems, by R. C. Schlitt, Student;
Industrial Service at the Bridgeport Works of the General Electric Co., by L. A. Autuori, Student. October 28. Attendance 13.

Inspection trip to the Electromatic Signal Corp. Various devices which actuate the operation of traffic lights were shown. November 4. Attendance 14.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these founder societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August, when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES—OCTOBER 1-31, 1930

Unless otherwise specified, books in this list have been presented by the publishers; the Institute assumes no responsibility for any statement made as they are taken from the preface or the text of the book. All books listed may be consulted in the Engineering Societies Library.

AIRCRAFT INSTRUMENTS.

By C. J. Stewart. N. Y., John Wiley & Sons, 1930. 269 pp., illus., plates, tables, 9 x 6 in., cloth. $5.50.

Treats of the design, construction, functioning and fitting of the instruments needed by the pilot to inform him as to his speed, altitude, position and the condition of his engine. The author is in charge of aircraft instrument design for the British Air Ministry.

INGENIEUR-ARCHIV, Bd. 1, No. 1; Dec. 1929.

Berlin, Julius Springer, 1929. 122 pp., 11 x 8 in., paper. 9.60 r. m.

A new periodical edited by Professor R. Grammel of the Stuttgart Technical High School, which will appear at irregular intervals. The magazine will endeavor to promote intercourse between scientific research and engineering practise, especially the relations of mechanics and thermodynamics to mechanical and structural engineering.

The first number contains eight papers presenting the results of recent research work upon such questions of importance as the strength of cylindrical shells under loads that are not axially symmetrical, the unsymmetrical bending of thin circular plates, and the stresses in shaft timber.

HARVARD BUSINESS REPORTS; compiled by and published for the Graduate School of Business Administration . . . Harvard University: v. 8; Cases on the Motion Picture Industry, with commentaries by Howard Thompson Lewis. N. Y., McGraw-Hill Book Co., 1930. 687 pp., 9 x 6 in., cloth. $7.50.

The sixty-six cases in this volume present actual problems in the motion-picture industry and the methods with which they have been met and solved. Many of the administrative problems discussed have their counterparts in other types of business.

JAHRBUCH DER WISSENSCHAFTLICHEN GESELLSCHAFT FUR LUFTFAHRT E. V., 1929.

Mün. u. Ber., R. Oldenbourg [1930] 227 pp., illus., diagrs., 12 x 9 in., cloth. 26 r. m.

Contains the proceedings of the eighteenth meeting, a list of members and officers, and the papers presented before the society. Among these are papers upon the Do-X airship, the development of the Junkers airplane oil-engine, rivetted joints in thin sheets, the use of electron in airplane construction, long-distance flying, and other topics of current interest.

KURBELWELLENBRÜCHE UND WERKSTOFFRAGEN.

By Kurt Matthaes. (Luftfahrtforschung, v. 8, No. 4). Mün. u. Ber., R. Oldenbourg, 1930. 30 pp., illus., 11 x 8 in., paper. 6.20 r. m.

The author has investigated the problem of crank-shaft breaking in six-cylinder straight-line aircraft engines. He concludes that the breakage is caused by defects in construction, not by faulty material.

THE AIRPLANE.

By Frederick Bedell and Theodore E. Thompson. Rewritten and enlarged. N. Y., D. Van Nostrand Co., 1930. 371 pp., illus., diagrs., 9 x 6 in., cloth. $3.75.

This book aims to give a simple, well-rounded treatment of the principles of airplane flight which will be of use to flyers and designers, and also meet the needs of general readers. Five new chapters have been added to this edition, treating of the airplane engine, of various types of aircraft, and of instruments. The construction and equipment of the "Spirit of St. Louis" are described in detail.

AUTOBIOGRAPHICAL AND OTHER WRITINGS.

By Alan A. Campbell Swinton. N. Y., Longmans, Green & Co., 1930. 181 pp., illus., ports., 9 x 6 in., cloth. $3.50.

A. A. Campbell Swinton was active in a variety of scientific and industrial pursuits. In 1887, after an apprenticeship at the Armstrong works, he settled in London as a consulting electrical engineer, and designed and constructed various lighting installations and railways. He was also associated with the development of the Parsons turbine, and with the utilization of X-rays and the development of radio. This book, containing his biography and a collection of his addresses and verse, has many references of historic interest on the development of telephony, electric lighting, etc.

FOUNDATIONS FOR HUMAN ENGINEERING.

By Charles R. Gow. N. Y., Macmillan Co., 1930. 226 pp., port., 8 x 5 in., cloth. $1.60.

These talks, by the Professor of Humanics at the Massachusetts Institute of Technology, discuss social and economic problems that confront the young engineer. They give him much sound advice upon his attitude toward his employer, his associates and his subordinates, as well as to his behavior in many other situations that arise in life.

IMPURITIES IN METALS.

By Colin J. Smithells. 2d edition. N. Y., John Wiley & Sons, 1930. 190 pp., illus., diagrs., tables, 10 x 6 in., paper. $5.00.

Dr. Smithells gives a systematic account of our present knowledge concerning the extent to which the structure, mechanical and electrical properties, and the corrodibility of commercial metals are affected by the impurities and minor constituents that are always present in them. He also discusses recent developments in metallographic technique, particularly in the application of X-rays to the study of the structure of metals. The new edition is thoroughly revised and considerably expanded.

INGENIEUR UND WIRTSCHAFT; DER WIRTSCHAFTS-INGENIEUR.

By W. Prion. Berlin, Julius Springer, 1930. 172 pp., 10 x 6 in., paper. 6 r. m.

The author, a professor of economics at the Technical High School in Berlin, here discusses the problem of proper training in economics for engineers. The inadequacies of present methods are discussed, and plans for a more useful coordination of the subjects are presented. Should interest educators.

AN INTRODUCTION TO THE STUDY OF WAVE MECHANICS.

By Louis de Broglie. N. Y., E. P. Dutton & Co., 1930. 249 pp., 9 x 6 in., cloth. $4.25.

This account of the theory of wave mechanics originated by Dr. de Broglie will be welcomed by physicists generally. Beginning with the ideas underlying the theory, he develops the subject in logical sequence. The principal of indeterminateness is discussed, and recent experimental work on electronic diffraction described.

JAHRBUCH 1930 DER DEUTSCHEN VERSUCHSANSTALT FUR LUFTFAHRT, E. V., Berlin-Adlershof. Edited by Wilh. Hoff. Mün. u. Ber., R. Oldenbourg, 1930. 688 pp., illus., diagrs., tables, 12 x 9 in., cloth. 58 r. m.

The yearbook of this active research institution is an important contribution to aeronautic literature. In addition to reports on the activities of the organization, it contains reports on fifty-eight researches completed during the past year. The reports cover a wide variety of practical and theoretical questions relating to aerodynamics, statics, engines, materials, aviation and radio telegraphy.

DER LEISTUNGSFAKTOR.

By G. Scharowsky. (Siemens-Handbücher, bd. 7) Ber. u. Lpz., Walter De Gruyter & Co., 1930. 197 pp., illus., 8 x 6 in., cloth. 7.50 r. m.

Reviews the importance, source, and effects of reactive power, and discusses the methods of improving the power factor which have been devised. The measurement and computation of reactive power are also discussed. The book is based on the researches and experience of Siemens & Halske and the Siemens-Schuckertwerke.

DER MENSCH IM FABRIKBETRIEB. Edited by F. Ludwig. Berlin, Julius Springer, 1930. 204 pp., illus., diagrs., tables, 9 x 6 in., bound. 16.50 r. m.

The nine addresses here collected under the general theme of the man in industry are those delivered before the society of German Factory Engineers in 1928/1929. They discuss various factors that affect the health and efficiency of workmen, including such matters as the prevention of fatigue, the psychology of accidents, lighting in relation to production, the influence of dust on output, the arrangement of workrooms, hygienic measures for women, and industrial cooperation.

METALLURGISTS AND CHEMISTS' HANDBOOK.

Compiled by Donald M. Liddell. 3rd edition. N. Y., McGraw-Hill Book Co., 1930. 847 pp., tables, 7 x 4 in., fabrikoid. $5.00.

A useful collection of physical, economic, chemical and mechanical data constantly wanted by chemists and metallurgists, in a book of convenient size for the coat pocket. The compiler, an experienced engineer, has had especially in mind the need of explorers and others without access to libraries. The new edition has been carefully revised and contains much added material.

THE NEW PHYSICS.

By Arthur Haas. 3rd edition. N. Y., E. P. Dutton & Co., 1930. 172 pp., illus., diagrs., tables, 8 x 5 in., cloth. $2.15.

The electromagnetic theory of light, molecular statistics, the electron and quantum theories, the theory of the chemical elements, and the theory of relativity and gravitation are the topics that Dr. Haas discusses. Without any use of mathematics he gives a clear, general view of the ideas that now are interesting physicists, and of modern views upon the constitution of matter and the laws that govern it. Readers without special training in physics will find the book intelligible.

SCIENCE AND THE SCIENTIFIC MIND.

By Leo E. Saidla and Warren E. Gibbs. N. Y., McGraw-Hill Book Co., 1930. 506 pp., 8 x 6 in., cloth. $3.00.

Contains twenty-four essays by such past and present scientific leaders as Tyndall, Huxley, Shaler, Pupin, Millikan and Haldane, discussing Science, the Scientific Mind, Scientific Motive, Science and Culture, the Place of Science in a Liberal Education, Science and Civilization, and Science and the Future. While intended primarily as a textbook in composition, readers who wish an insight into the mental attitude or habit of thought of the scientist will find the book useful.

SELEKTIVSCHUTZ.

By Fritz Kesselring. Berlin, Julius Springer, 1930. 181 pp., illus., 9 x 6 in., bound. 19 r. m.

Dr. Kesselring is chiefly interested in the general conceptions that underlie modern methods of protecting electrical equipment, and that are of importance independently of current practise in the construction of protective apparatus. He therefore directs himself to a study of the changes to which electrical systems are subjected by short-circuiting, especially the distribution of current and voltage in short-circuited or grounded lines. The theory of selective relays is discussed at some length.

SIEMENS JAHRBUCH, 1930. Berlin, V. D. I. Verlag, 1930. 562 pp., illus., diagrs., port., 8 x 6 in., cloth. 12 r. m.

The yearbook presents a great number of papers by various members of the technical staffs of the cooperating firms. The central theme this year is the distribution and use of energy, and the papers discuss new inventions and ideas about power cables, reaction turbines, large transformers, switching apparatus, telephone cables and apparatus, automatic control, etc. Other papers deal with electrical mining and metallurgical equipment, electric welding, sound films and other topics. The book is popular in style and is profusely illustrated.

THEORY OF ELECTRICAL ARTIFICIAL LINES AND FILTERS.

By A. C. Bartlett. N. Y., John Wiley & Sons, 1930. 155 pp., 9 x 5 in., cloth. $3.50.

A general introduction to the theory of repeated networks, as used in modern telephony and telegraphy, intended to enable the reader to enter the vast literature of the subject. The author is a member of the research staff of the General Electric Co., Ltd.

DER WERKZEUGMASCHINEN-UND WERKZEUGBAU: FRITZ WERNER AKTIENGESELLSCHAFT, Berlin,

By Hans Dominik. (Musterbetriebe Deutscher Wirtschaft, bd. 17). Berlin, S. Hirzel, 1930. 80 pp. illus., graphs, forms, 9 x 6 in., boards. 2.75 r. m.

Describes the organization and methods of these well-known tool manufacturers, as an example of good practise in factory organization and management. The various departments are explained in detail, with emphasis on methods for controlling quality of products.

WHO'S WHO IN RAILROADING; United States, Canada, Mexico, Cuba. 1930 edition. N. Y., Simmons-Boardman Publishing Company, 1930. 579 pp., 9 x 6 in., cloth. $8.50.

A re-issue of the "Biographical Directory of Railway Officials of America" in an improved form. The biographies have been enlarged by the addition of personal information to the former purely official data, and the scope has been extended by the inclusion of individuals closely connected with railroading, although not railroad officials, such as manufacturers of equipment, economists, regulatory authorities, etc. These improvements add considerably to the value of the work.

PRÜFANSTALT FÜR FEUERFESTE MATERIALIEN.

By L. Litinsky. Leipzig, Otto Spamer, 1930. (Monographien zur Feuerungstechnik, bd. 11). 127 pp., illus., 9 x 6 in., paper. 7 r. m.

A useful review of the best and most used apparatus for the analysis and testing of refractory materials, as used in the principal German laboratories.

SCHNITTE UND STANZEN, BD. 2; BIEGESTANZEN UND BIEGE-VERBUNDWERKZEUGE.

By Ernst Göhre. Lpz., Otto Spamer, 1930. 230 pp., illus., 9 x 6 in., paper, 20.-r. m; bound, 23 r. m.

The second volume of this treatise on punching and stamping treats of bending dies. The methods of achieving various forms are described in detail the aim being to assist the engineer in designing suitable dies for a desired shape. Further volumes will discuss drawing dies and die construction.

DIE VENTILATOREN.

By E. Wiesmann. 2d edition. Berlin, Julius Springer, 1930. 309 pp., illus., diagrs., tables, 9 x 6 in., bound. 24 r. m.

A text on the design, construction and uses of centrifugal blowers. Theoretical principles are developed quite fully, and the data and formulas needed by designers are presented. A number of large installations for ventilating tunnels and mines, for heating and drying, and for conveying are described.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 West 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

CHIEF ELECTRICAL TESTER, not over 43. Must be thoroughly experienced executive to take charge of testing department. Must be a graduate electrical engineer whose practical experience covers a period of years on a-c. and d-c. motor and generator engineering and testing. Must be capable of advancing solutions of problems arising in the course of testing small and large electrical motors and generators of various types. Apply by letter giving a complete outline of technical training and practical experience. State names and addresses of past employers with the nature of the position held at each place, present affiliation, age, nationality, social connection and salary expected. Location, East. W-1410.

GRADUATE ELECTRICAL ENGINEER, experienced in application of synchronous motors to compressors (air and ammonia). This experience essential. Apply only by letter. Location, New Jersey. W-1762.

ELECTROCHEMIST, with knowledge and experience covering varnishes, thinners, glues, carbons and their applications to electrical resistors. Apply by letter. Location, East. W-1951.

MEN AVAILABLE

GRADUATE ELECTRICAL ENGINEER, 24, single. Three months' public utility experience and two months' shop work. Now teaching mathematics and physics in Kansas City. C-8221.

ELECTRICAL ENGINEER, age 27, M. S., Iowa State College, 1930. B. S., Pennsylvania State College, 1925. Experience in calculation of a-c. distribution, testing, and as graduate assistant in electrical engineering. Desires position in testing of miscellaneous electrical machinery, or other technical work. Experimental work will be considered if it seems suitable. C-3202.

1929 GRADUATE ELECTRICAL ENGINEER, single, age 23. Has just completed 14 months on G. E. Test Course. Available immediately. Experience covers work in radio and vacuum tube laboratories and testing all types of electrical equipment. Location, preferred New York. C-1879.

ENGINEER, ELECTRICAL, eleven years' experience in power station construction and industrial electrical equipment. Three and one-half years technical training. Age 33, married. Experienced in purchasing and inspection. Location, immaterial. Available at once. C-8321.

GRADUATE ELECTRICAL ENGINEER, foreign and American universities, 31, married. G. E. Test 1924-26. Electrical design and construction experience on a coal-breaker project. Also utility test and central station design experience. Desires permanent connection with a consulting firm. Free to travel. C-5912.

MECHANICAL AND ELECTRICAL ENGINEER, after 13 years with one of the leading corporations, is now available. Experience covers all phases of design, construction and operation of modern turboelectric generating stations for public and private utilities. This includes putting existing plants in more efficient operation at moderate cost. C-8249.

ELECTRICAL ENGINEER, 32, married. Nine years' general testing and development experience, including railway equipment with exceptional practical knowledge of power mercury arc rectifiers. Desires position in test or operating departments of public utility or electric railroad, South, East or Chicago. C-7875.

ELECTRICAL AND MECHANICAL ENGINEER, university graduate, 36, twelve years' comprehensive experience in generation, transmission and distribution of electric power. Four

years with large consulting engineering firm, two years with Westinghouse Electric & Manufacturing Co. Executive ability. Foreign languages. Desires position with public utility, consulting engineers, industrial, or export firm. C-8195.

GRADUATE ELECTRICAL ENGINEER, five years of engineering experience. Has traveled extensively in United States as supervising engineer and company representative for national organization. Experienced in sound and theater engineering. Desires location with commercial organization as field representative or office assistant. Will accept domestic or foreign assignment. Remuneration of secondary consideration. C-8231.

GRADUATE ELECTRICAL ENGINEER, Norwegian Institute of Technology 1923. Age 33, married. Six years' experience in design and construction of steam-electric generating stations and distribution substations. Desires position with public utility or consulting engineer here or abroad. C-8278.

GRADUATE, 1930, B. S. in E. E. Seven months' experience in design department of a public utility. Desires position relating to power generation, transmission or distribution. Age 21. Location, New York City or vicinity. C-8293.

ELECTRICAL ENGINEER, American. Street railway, main line electrification, mining and public utilities. Twenty years in Latin America as engineer and manager. Has done considerable Diesel engine and refrigeration work. B-5912.

ELECTRICAL ENGINEER, graduate. Approximately 12 years' practical experience maintaining and engineering, both detail and general, low-voltage power plants. Work consisted of power calculations, estimating cost of job, floor plan layouts, circuits, power boards, batteries and charging equipment, leads and conduits, correspondence and records. C-8328.

PLANT ENGINEER, electrical and mechanical, 43. Experienced executive and organizer, dealing with men and problems in industrial plants and utilities. Desires a position where initiative and energy are required. Eighteen years' experience in management, maintenance, operation, construction, plant layout, estimating, budgeting and time study. Four years in electrical designing. C-8285.

GRADUATE ELECTRICAL ENGINEER, 35, married. Three years' experience in design, construction, operation of distribution system, light and power company. Three years design, construction and operation street railway, one year assistant chief engineer of same. Four years assistant electrical engineer head office large foreign public utilities. United States public utility preferred. C-5091.

GRADUATE ELECTRICAL ENGINEER, 24. One year's experience on the Westinghouse graduate student course and seven months on the testing course. Desires a permanent position with a utility company or steel company along the lines of plant planning and operating engineering. References will be furnished on request. Available on month's notice. C-7431.

TECHNICAL GRADUATE, age 35, married. Princeton B. S. 1916. Eleven years' experience large eastern public utility as cadet engineer, inspection, and electrical tests on transformers, motors, illumination and dielectric cable losses. One and one-half years research work with instrument company. Desires position, Philadelphia or vicinity. C-8350.

ELECTRICAL ENGINEER, B. S. degree, age 33, large electrical manufacturers sales course training, 5¾ years direct sales and 2½ years technical advertising electrical and mechanical equipment for industrials and railroads. Desires sales engineering position, electrical or mechanical equipment manufacturer. References. Location, will consider. Available immediately. C-7545.

SALES ENGINEER, three years' experience with metal flux used in brass foundries. Large acquaintance in non-ferrous casting industry. Familiar with foundry practise and methods, both technical and practical. Knowledge of chemistry as applied to alloys. Engineering design ability. Valuable on sales and equipment used in manufacturing castings. B-5207.

GRADUATE ELECTRICAL ENGINEER, 27, experienced in power distribution; wishes to work into broader and more academic field of activity. Has strong inclination toward literary work, and desires to combine this interest with his technical knowledge in an advantageous way such as popularizing scientific ideas for publication. Available, two weeks' notice. C-2967.

ELECTRICAL DESIGN DRAFTSMAN OR CHECKER, 30, single. Third year night engineering, twelve years' experience covering design of power plants, substations and network systems. Desires connection with public utility. Location, immaterial. Available on two weeks' notice. B-8628.

SALES ENGINEER, 32, single. Graduate electrical engineer. General Electric Test and engineering experience with large utility. Experienced in sales of line hardware, distribution, high-voltage and street lighting equipment, transmission conductors and lead cable. Available at once. Location, Pacific Coast. B-2624-309-C-11.

GRADUATE ELECTRICAL ENGINEER, 30. Two years' railroad shop and power plant experience, 4¾ years in large eastern railroad electrical engineer's office, drafting and design, appraisal electrical and power plant machinery, investigation and reports of engineering projects; 19 months electrician U. S. Shipping Board, Diesel and Diesel-electric motorships. Speaks Spanish. C-8160.

SALES ENGINEER, 27, single, graduate. Engineering and sales experience of five years with leading control manufacturer. Desires position with sales department of an electrical concern or motor control specialist for a fast growing electrical jobbing house. C-8390.

SALES ENGINEER, technical graduate, age 37, single. Westinghouse test floor and shop experience. Approximately ten years' successful sales record selling electrical and mechanical apparatus to central station, steam and electrical railway and marine industries. Prefer location, eastern seaboard states, but willing to consider good opportunity elsewhere. B-4274.

GRADUATE ELECTRICAL ENGINEER, B. S., degree. 1½ years with large electrical manufacturing concern in test and research departments. Also familiar with repair work on distribution transformers and other apparatus. Available on short notice. Location, preferred, New England or eastern part of country. C-8075.

ELECTRICAL ENGINEER, 32, Carnegie Technical graduate, 1929. One year in Prague Polytechnicum, one year in research and development with the Westinghouse. Four years in works management and accounting in Europe. Long experience in instructing. Speaks English, Russian; has knowledge of German and Czechoslovakian. Prefer research and development. Available immediately. C-8313.

GRADUATE ELECTRICAL ENGINEER, 28, one year Westinghouse test course, 6 years engineering for large eastern utility. Familiar design of distribution substations, customers' services, load dispatching and supervisory control system. Desires responsible position with public utility, or sales work with electrical manufacturer. C-8322.

SALES AND EXECUTIVE ENGINEER, trained at Worcester Polytechnic Institute. Six years' sales experience: Straight sales engineering, jobbing sales, promotion sales and management. Has had contact with electrical and mechanical companies. Traveled East, Middle West, South. Well acquainted with New England. C-5431.

ELECTRICAL ENGINEER, B. S. 1930, 26, single. Three and one-half years pipe fabricating and rolling mill experience. Would be interested in South American position or position on course in marine engineering on steamship. C-7477.

1930 GRADUATE ELECTRICAL ENGINEER, of one of the best engineer schools in the country, 25, single. Desires position. Especially interested in municipal work, editorial work. However, anything will be considered. Experience, one year with radio concern, also various business experience and college training in business and law. Can furnish best of references. C-8039.

EXPERIENCED TRANSFORMER ENGINEER, 35, graduate electrical engineer. Transformer design, manufacturer, tests, reports. Research work steel, insulation, capacitors, distribution systems. General Electric Test including motors, generators, transformers, etc. Sales engineering course Schenectady and Pittsfield. Desires permanent position design, sales or consultant with manufacturer, public utility. Location, preferred Eastern or Middle Eastern States. C-7321.

ELECTRICAL ENGINEER, graduate Union College, 1924. Age 28, married, good appearance. Two years telephone maintenance, 15 months General Electric Test Course, 4 years public utility operation, 15 years' commercial radio experience. Location, East. Available at once. C-4182.

SUPERINTENDENT OF DISTRIBUTION, 32, married, Degree E. E. Six years' electric utility experience covering engineering, construction, operation, maintenance of distribution lines, substations; sales and customer contact work. Employed, responsible for engineering and construction. Interested in position having responsibility for operation, maintenance, and improvement of property having 10,000 to 15,000 meters. C-5155.

1929 GRADUATE ELECTRICAL ENGINEER, 24, married. Desires employment of engineering nature in the construction or maintenance of electrical equipment. Eight months' General Electric Test experience, with a-c. and d-c. motors and generators, and industrial control apparatus. Available March 1st. Location preferred, Northern United States. C-7975.

GRADUATE ENGINEER, 24, 4 years out, now employed. Desires to establish a connection where extensive radio and talking movie experience can be used to advantage. Would be valuable to concern requiring services of engineer thoroughly familiar with Western Electric amplifiers, recording and reproducing equipment. Best of reference available. C-7902

DRAFTSMAN-DESIGNER, 44, married. Desires position with utility or construction company. Four years designing recording instruments for power plant use. Three years experimental work. Seven years a-c. transformer design and test. Five months high-pressure piping layout. Has equivalent of college education. Location, East. Available now. C-8353.

ELECTRICAL-MECHANICAL ENGINEER, university graduate, varied experience in design, construction and operation of power stations and industrial plants. Location, Middle West, Ohio or vicinity preferred. B-4144.

ELECTRICAL ENGINEER, degrees E. E., M. E. E. Registered engineer two states radio engineering, designed and supervised construction large broadcast station; also has been assistant professor, physics and electrical engineering southern university and professor, mathematics two southern colleges; desires radio engineering work or position teaching physics, electrical engineering, mathematics in South or Latin-America. C-5521.

ELECTRICAL GRADUATE, 36, long, diversified experience including South America, construction central stations, substations, maintenance, tests, inspections, distribution systems, pole lines. One year operating. Knows equipment and handling of men. Desires position

home, or representing manufacturer in Brazil. Languages, English, French, Portugese, working knowledge Spanish, German, Italian. Best references. Available immediately. C-2021.

CONSULTING ENGINEER, graduate electrical engineer of a reputable institution, who pursued 2 years graduate work in engineering and business administration, with 5 years' experience in responsible testing of a vast variety of electrical and mechanical equipment. Languages, German and French. Industrial accounting, patent experience. C-930.

GRADUATE ELECTRICAL ENGINEER, 1930, desires a position in the electrical engineering department of a large concern. Experience and advancement in the profession is prime object. Location, East, New York or Newark preferred. C-8251.

ELECTRICAL ENGINEER, graduate, 36, married. Twelve years' experience. Last five years with very active consulting engineer. Design, writing specifications and requisitions, cost estimates, industrial surveys, supervision of electrical installations covering new and extensions to existing power houses and industrial plants. Valuable to consulting engineer or industrial concern. Available at once. C-343.

ELECTRICAL ENGINEER, 21, single. Graduate of Pratt Institute, 1930. Has had drafting and clerical experience. Desires position in any electrical line with an opportunity for advancement. Location, immaterial. Available immediately. C-8380.

ELECTRICAL ENGINEER, three years cadet course with large utility; two years electrical engineering department of engineering and construction company. Familiar with public utility operation, also design and construction of power and lighting installations for industrial plants and public buildings. E. E. degree, Lehigh University. Desires permanent responsible position. Best references. C-8250.

ELECTRICAL ENGINEER, American, technical graduate, postgraduate work M. I. T. Three years Allis Chalmers test. Three years construction power plants, distribution lines, etc. Three years industrial plants, operation, maintenance. Eight years electric utilities including electrical operation, contact with large industrial customers. Speaks Spanish. Desires location, utility operating department, or as electrical engineer, industrial plant. A-4018.

SALES ENGINEER, technical education, two degrees. Ten years selling to eastern railroads, service with New York Central, Pennsylvania, Erie and Lackawanna, wide acquaintance signal, motive power, maintenance of way, test department. B-7881.

ELECTRICAL GRADUATE, B. S. degree, 29, single. Eight years' experience as designer and draftsman on power house, substations and switching stations for a large public utility company, and an engineering and construction company. C-8379.

GRADUATE ELECTRICAL-MECHANICAL ENGINEER, 36, desires connection public utility industrial firm power station operation, assistant to superintendent or engineer. Two years Westinghouse Test, power plant operation. Five years design, engineering, construction power plants, substations. Three years power station test, operation, maintenance. Three years electrical engineer industrial firm. Two years assistant to power engineer industrial concern. B-8379.

ELECTRICAL ENGINEER, unmarried, 22, desires to obtain employment in a power company which manufacturers generating apparatus. A graduate in electrical engineering. Was employed until recently in student course of large company. Has reference from this company. Location, immaterial. C-8342.

ELECTRICAL-MECHANICAL ENGINEER, several years' experience, design, development, and manufacture of high-grade devices, including radio, telephone, signal apparatus and automatic control systems for power and industrial plants. Executive ability. Married. References. Will consider suitable opening as designer or engineer. Reasonable salary with company offering opportunity. Prefer location, East. B-2395.

ELECTRICAL-DESIGN AND CONSTRUCTION ENGINEER, 35, married. University graduate, E. E. with nine years' practical experience in design, construction and operation of central stations and substations wishes position with public utility or engineering firm. Expert in automatic substations, control relay and metering. Location, immaterial. B-6560.

MAINTENANCE ENGINEER, B. S. in E. E. Experienced in construction and maintenance of theaters, office buildings, apartments and hotels. At present engaged in consulting practise on electric rate surveys. Has had editorial and teaching experience. Location, immaterial. C-8265.

ELECTRICAL ENGINEER, 27, experience includes; Westinghouse oscillograph operation; raw material inspection; pump, boiler and steam turbine tests; electrolysis survey of subway cables; electrical construction in finished buildings. Laboratory work preferred in Metropolitan area. C-8424.

MECHANICAL-ELECTRICALENGINEER, age 35, married. Experienced operation, layout, design and construction of industrial plants; design of special equipment; formulation of manufacturing methods and products. Has handled 400 men. Power plant equipment sales experience. Knowledge of foundries, paper mills, research laboratory, roofing, asphalt and milk plants, boiler and power plants. B-6555.

ELECTRICAL ENGINEER, M. I. T., 1926, 25 years old, single. Three years' testing laboratory experience with a large Eastern public utility. Cable testing and general substation instrument testing. Desires location with public utility or manufacturing company in the East. Available immediately. A-2630.

UTILITIES EXECUTIVE, solicits inquiries. Operating executive experience covering full responsibility on policy, public relations, business promotional and reorganization work with background of professional experience in engineering and financial investigations, audits, rate engineering, acquisition and bankers reports. Last position assistant to president. Trained as engineer and accountant. Age 39, American. C-6700.

ELECTRICAL ENGINEER, age 29, married, Canadian. I. C. S. graduate. Fifteen years' practical experience; construction and maintenance. Desires position as chief in factory. Canadian location preferred. C-8439.

ELECTRICAL ENGINEER, B. S. degree, 37, married. Five years' radio laboratory, electrical writing, and electrical reporting experience. Two years' talking picture experience. Six months radio patent specification work. New York City and vicinity preferred B-1204.

ELECTRICAL ENGINEER, 1930 graduate, 25, single. Two years' drafting experience. Desires engineering work with opportunity for advancement. Location, immaterial. C-8437.

ELECTRICAL ENGINEER, B. S. degree, 29, Westinghouse operating course, one year underground transmission layout; five years' overhead and underground electric distribution experience. Desires position in electric distribution field, with future. References. Location, immaterial. B-9976.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of November 18, 1930, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

ANDERSON, STEWART W., Prof. of Elec. Engg., Virginia Military Institute, Lexington, Va.

CONWELL, ROLLIN N., Transmission and Substation Engr., Public Service Elec. & Gas Co., Newark, N. J.

HAYLER, GEORGE E., Jr., Engineer, Henry L. Doherty & Co., New York.

JONES, REGINALD L., Director of Apparatus Development, Bell Telephone Labs. Inc., New York.

To Grade of Member

BERRY, J. H., Supt., Power Station and Substations, Virginia Elec. & Pr. Co., Norfolk, Va.

BLAIN, RAY, Telephone Plant Engr., Signal Corps, U. S. Army, Columbus, Ohio.

BLATTNER, DAVID G., Special Transmission Instruments Development Engr., Bell Telephone Labs., Inc., New York.

BURMEISTER, HARRY W., Field Engr., Commonwealth Edison Co., Chicago, Ill.

CROSBY, LEMUEL S., General Personnel Supervisor, American Tel. & Tel. Co., New York.

DINWIDDIE, JAMES A., Toledo Manager, Westinghouse Elec. & Mfg. Co., Toledo, O.

FRONMULLER, T. C., Asst. Engr., Pacific Gas & Elec. Co., San Francisco, Calif.

HLAVAC, J. GEORGE, Asst. Elec. Engr., Central Hudson Gas & Elec. Co., Poughkeepsie, N. Y.

HOSFELD, DAVID C., Plant Results Engr., American Tel. & Tel. Co., New York.

LIBBY, ALBION D. T., Elec. Engr. and Patent Attorney, Splitdorf Elec. Co., Newark, N. J.

LITTLE, A. W., Sales Engr., General Elec. Co., Toledo, Ohio.

MACKAY, GEORGE M. J., Research Engr., General Elec. Co., Schenectady, N. Y.

McINTOSH, CROMWELL, Asst. to Vice-Pres. and Gen. Mgr., Buffalo General Elec. Co., Buffalo, N. Y.

McLENEGAN, DAVID W., Commercial Engineer, General Electric Co., Schenectady, N. Y.

PABST, WILLIAM, Head of Elec. Dept., Brooklyn Technical High School, Brooklyn, N. Y.

RACE, HUBERT H., Research Engr., General Electric Co., Schenectady, N. Y.

RANSOM, PAUL, Elec. Engr., Utah Apex Mining Co., Bingham Canyon, Utah.

REDMON, ROY S., Engr., Stone & Webster Engg. Corp., Pottsville, Pa.

RICH, RICHARD A., Jr., Field Elec. Engr., General Elec. Co., New York.

RICK, ALVIN H., Asst. Commercial Engr., Elec. Bond & Share Co., New York.

SCOTT, ROBERT C., Elec. Engr., Stone & Webster Engg. Corp., Boston, Mass.

STUART, JAMES E. B., Jr., Distribution Engr., United Elec. Lt. & Pr. Co., New York.

WEINBACH, MENDELL P., Prof. of Elec. Engg., University of Missouri, Columbia, Mo.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before December 31, 1930.

Adams, E. G., Harvard University, Boston, Mass.
Albrecht, E. A., (Member), General Electric Co., Erie, Pa.
Aldrich, J. B., Detroit Edison Co., Detroit, Mich.
Alfonso, M. J., Dept. of Street Railways, Detroit, Mich.
Anderson, L. T., Bell Tel. Laboratories, Inc., New York, N. Y.
Angus, F. W., Bell Tel. Co. of Canada, Montreal, Que., Can.
Arnold, H. R., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Auckerman, U. H., Chesapeake & Ohio Ry., Richmond, Va.
Baldwin, P., R C A Photophone, Inc., Philadelphia, Pa.
Banos, A., Jr., Johns Hopkins University, Baltimore, Md.
Barnett, A. H., 170 South Mountain View, Los Angeles, Calif.
Barret, J. T., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Bates, H. C., Westinghouse Elec. & Mfg. Co., East Springfield, Mass.
Beal, J. D., Jr., Northeastern University, Boston, Mass.
Belayeff, O. I., New York State Railways, Syracuse, N. Y.
Bell, G. A., Hydro-Electric Power Comm. of Ontario, Toronto, Ont., Can.
Berresford, A. B., Albany Medical College, Albany, N. Y.
Berwick, V. H., General Railway Signal Co., Rochester, N. Y.
Bills, T. S., Fox Movietone News, New York, N. Y.
Bornemann, F. E., Rensselaer Polytechnic Institute, Troy, N. Y.
Boyer, H. L., General Electric Co., Fort Wayne, Ind.
Brace, G. A., U. S. Patent Office, Washington, D. C.
Bradbury, G. C., Bell Telephone Laboratories, New York, N. Y.
Braunwarth, W. W., American Tel. & Tel. Co., Philadelphia, Pa.
Breazeale, W. M., Western Electric Co., Kearny, N. J.
Bridges, J. A., Southern California Tel. Co., Los Angeles, Calif.
Bridges, J. J., Jr., General Electric Co., Erie, Pa.
Brigham, H. B., Byllesby Engg. & Mgt Corp., Oklahoma City, Okla.
Brilmayer, E. W., Union Gas & Electric Co., Cincinnati, Ohio
Brooks, P. J., Penna. Power & Light Co., Allentown, Pa.
Brown, A. D., Allis-Chalmers Mfg. Co., Buffalo, N. Y.
Burgess, M. S., American Tel. & Tel. Co., New York, N. Y
Burnham, E. B., Southwestern Bell Tel. Co., St. Louis, Mo.
Burns, A. E., 1958 East 29th St., Brooklyn, N. Y.
Burton, M. W., Westinghouse Electric Elevator Co., Chicago, Ill.
Bussell, C. W., General Railway Signal Co., Rochester, N. Y.
Campbell, C. J., Hankscraft Co., Madison, Wis.
Campbell, C. R., Jr., Otis Elevator Co., Yonkers, N. Y.
Canfield, W., Public Service Co. of Okla., Tulsa, Okla.
Cargill, N. V., General Electric Co., Schenectady, N. Y.
Carr, C. R., Leeds & Northrup Co., Philadelphia, Pa.
Chase, R. W., University of Texas, Austin, Tex.
Cherry, C. E., University of California, Berkeley, Calif.
Chin, L. Q., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Cilley, P., Boston Insulated Wire & Cable Co., Boston, Mass.
Claves, J., United Electric Lt. & Pr. Co., New York, N. Y.
Cobb, E. E., Public Service Co of Okla., Weleetka, Okla.
Codling, E. P., Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Colyer, J. F., Fairbanks, Morse & Co., Jacksonville, Fla.
Conlon, F. B., Pennsylvania Railroad, Philadelphia, Pa.
Conner, J. L., (Member), Philadelphia Electric Co., Philadelphia, Pa.
Connors, W. I., Brooklyn Edison Co., Brooklyn, N. Y.
Conrad, I. F., General Electric Co., St. Louis, Mo.
Cowan, S. O., University of South Carolina, Columbia, S. C.
Coy, C. D., Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio
Crabtree, L. F., Automatic Electric Inc., Chicago, Ill.
Crouter, L. E., Mountain States Tel. & Tel. Co., Butte, Mont.
Deady, J. A., Jr., Public Service Elec. & Gas Co., Newark, N. J.
DeBaene, E. C., Detroit Edison Co., DelRay, Mich.
Delchamps, H. J., (Member), Bell Telephone Laboratories, New York, N. Y.
Delthony, F. F., Brooklyn Navy Yard, Brooklyn, N. Y.
Detwiler, W. F., 1929 Burlington Ave. N., St. Petersburg, Fla.
Dickinson, C. H., 311 E. High St., Charlottesville, Va.
Dubinski, L., Pacific Gas & Electric Co., Storrie, Calif.
Eakins, W. V., General Electric Co., Buffalo, N. Y.
Eargle, W. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Edwards, R. J., American Tel. & Tel. Co., New York, N. Y.
Ellicock, A. B., Bell Telephone Laboratories, Inc., New York, N. Y.
Elliott, C. L., Austin Municipal Water & Light Plant, Austin, Minn.
Ferri, L. F., Ohio Public Service Co., Cleveland, Ohio
Ferris, R. J., (Member), Illinois Bell Tel. Co., Chicago, Ill.
Fischbach, H. K., U. S. Engineer Office, Huntington, W. Va.
Fitzgerald, A. E., General Electric Co., Lynn, Mass.
Fjord-Christensen, J., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Foisy, E. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Foley, W. R., Custom House, Norfolk, Va.
Frew, R. A., Western Electric Co., Kearny, N. J.
Frink, F. W., General Electric Co., Schenectady, N. Y.
Fyler, G. W., General Electric Co., Schenectady, N. Y.
Gant, E., West Penn Public Service Co., Parkersburg, W. Va.
Garber, L. H., American Tel. & Tel. Co., Denver, Colo.
Gilroy, J. W., Electrical Research Products, Inc., Salt Lake City, Utah
Gorman, F. W., Ohio Brass Co., El Paso, Tex.
Grant, R. H., General Electric Co., West Lynn, Mass.
Grogan, P. H., General Cable Corp., Rome, N. Y.
Gulow, A., Northwestern Mfg. Co., Milwaukee, Wis.
Gustanoff, A. L., 1682 E. 28th St., Brooklyn, N. Y.
Guth, C. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Guyatt, C. W., Public Service Elec. & Gas Co., Newark, N. J.
Haeff, A. V., Calif. Inst. of Technology, Pasadena, Calif.
Hagen, V. E., New York Edison Co., New York, N. Y.
Halvarson, T., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Hamma, W. C., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Hammond, A. A., (Member), Lafayette High School, Buffalo, N. Y.
Hanlon, H. W., 2129 Telephone Bldg., Kansas City, Mo.
Harazim, F., 428 E. 77th St., New York, N. Y.
Hardin, R. C., Western Union Telegraph Co., New York, N. Y.
Harris, H., Western Electric Co., New York, N. Y.
Hart, G. W., New York & Queens Elec. Lt. & Pr. Co., Long Island City, N. Y.
Hayward, S. K., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Henry, A. L., Rensselaer Polytechnic Institute, Troy, N. Y.
Hensel, W. G., Bell Tel. Laboratories, Whippany, N. J.
Hill, H. E., Bell Telephone Laboratories, New York, N. Y.
Hite, G. O., Firestone Tire & Rubber Co., Akron, Ohio
Holmes, C. L., Washington College, Pullman, Wash.
Huss, P. O., University of Michigan, Ann Arbor, Mich.
Hyde, H. H., University of California, Berkeley, Calif.
Irwin, F. B., Portland General Electric Co., Portland, Ore.
Isaacs, J. S., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Jobe, C. L., Okla. Gas & Electric Co., Oklahoma City, Okla.
Jones, E. A., New York Telephone Co., New York, N. Y.
Jones, N. K., Union Elec. Lt. & Pr. Co., Webster Groves, Mo.
Jorstad, H. C., Westinghouse Elec. & Mfg. Co., Detroit, Mich.
Karim, M. A., University of Michigan, Ann Arbor, Mich.
Kaynor, H. J., United Air Cleaner Corp., Chicago, Ill.
Kelly, E. P., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Kennedy, F. E., General Electric Co., Philadelphia, Pa.
Kerr, W. H., Pacific Gas & Electric Co., San Rafael, Calif.
Kirk, W. C., Ken-Rad Corp., Owensboro, Ky.
Klatzko, D., U. S. Naval Base, Brooklyn, N. Y.
Klein, W. S., Mackay Radio & Telegraph Co., Seattle, Wash.
Klinefelter, O. H., N. J. Bell Tel. Co., Newark, N. J.
Klingenstein J., Federal Bldg., Chicago, Ill.
Kocmich, E. G., Jr., Western Electric Co., Chicago, Ill.
Kohler, E., Jr., Museum of Science & Industry, Chicago, Ill.
Larason, G. E., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Law, R. R., Iowa State College, Ames, Iowa
Leffler, H. W., American Tel. & Tel. Co., Denver, Colo.
Lehman, C. D., National Board of Fire Underwriters, New York, N. Y.
Logan, G. F., Anglo-Chilean Nitrate Co., New York, N. Y.
Lubkin, S., Otis Elevator Co., Yonkers, N. Y.
Lukoff, B. A., Pacific Gas & Electric Co., San Francisco, Calif.
Manfredo, I. H., General Electric Co., Schenectady, N. Y.
Marples, H. F., 3316 170th St., Flushing, N. Y.

Martin, P. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Mason, H. E., Okonite Co., Passaic, N. J.
Mathis, H. H., R. C. A., Victor Co., Camden, N. J.
Maxfield, F. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
McCloska, F. W., Chicago District Electric Generating Corp., South Chicago, Ill.
McMurdo, C. E., Chesapeake & Potomac Telephone Co., Richmond, Va.
Meacham, L. A., Bell Telephone Laboratories, New York, N. Y.
Meinzer, A. E., Underwriters Laboratories, Chicago, Ill.
Merriam, W. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Metcalf, E. C., General Electric Co., Erie, Pa.
Michelson, E. L., Commonwealth Edison Co., Chicago, Ill.
Middleton, L. H., Schwarze Electric Co., Adrian, Mich.
Mitchel, R. H., A. C. Spark Plug Co., Flint, Mich.
Moench, H. A., Rose Polytechnic Institute, Terre Haute, Indiana
Munzer, L. F., R C A Communications, Inc., Tuckerton, N. J.
Myers, H. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Nelson, C. R., American Tel. & Tel. Co., Philadelphia, Pa.
Nelson, L. A., General Electric Co., Schenectady, N. Y.
Newhouse, R. C., Bell Telephone Laboratories, New York, N. Y.
North, J. H., American Tel & Tel. Co., Washington, D. C.
Oldham, G. G., Kansas City Power & Light Co., Kansas City, Mo.
Outt, J. R., Mass. Institute of Technology, Cambridge, Mass.
Pavely, W. T., Union Gas & Electric Co., Cincinnati, Ohio
Pearce, H., General Railway Signal Co., Rochester, N. Y.
Petersen, F. C., Western Union Telegraph Co., New York, N. Y.
Peterson, W. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Pingon, A. C., Compagnie Francais Thomson-Houston, Schenectady, N. Y.
Porras, M., A., Cia. Electrica Parralense S. A., Chihuahua, Chih., Mexico
Pulaski, S. S., Time-O-Stat Controls Co., Elkhart, Indiana
Rappaport, M., Autofloat Corp. of America, College Point, L. I., N. Y.
Raye, G. W., 62 High St., Eastport, Me.
Richardson, F. A., American Tel. & Tel. Co., Denver, Colo.
Richardson, J. R., Allied Engineers, Inc., Grand Rapids, Mich.
Riley, E. C., City of Saskatoon, Saskatoon, Sask., Can.
Roome, G. R., Jersey Central Power & Light Co., Asbury Park, N. J.
Ruehrmund, L. G., 236 Blaine Ave., Marion, Ohio
Sallemi, J. B., Commonwealth Edison Co., Chicago, Ill.
Salma, E. A., Cooper Union, New York, N. Y.
Sanders, V., New York Edison Co., New York, N. Y.
Sanger, J. H., General Electric Co., Schenectady, N. Y.
Schuetz, R. F., National Broadcasting Co., New York, N. Y.
Seymour, M. W., Arthur H. Abbott, Inc., Boston, Mass.
Shainberg, G., Missouri Power & Light Co., Brookfield, Mo.
Shaner, R. E., Stone & Webster Engg. Corp., Boston, Mass.
Sheahan, R. E., Harvard Engineering School, Cambridge, Mass.
Shepherd, P. A., Wagner Electric Corp., Buffalo, N. Y.
Shimek, E. J., Rice Institute, Houston, Tex.
Shutt, E. H., (Member), General Cable Corp., St. Louis, Mo.
Silverberg, L. B., New York Tel. Co., New York, N. Y.
Simpson, W. G., 37 Oakland St., Irvington, N. J.
Sinclair, R. E., Detroit Edison Co., Detroit, Mich.
Slater, S. I., Ergon Electric Corp., Brooklyn, N. Y.
Slezak, L. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Smith, A. Z., R C A Communications, Inc., Riverhead, N. Y.
Smith, L., Puget Sound Power & Light Co., Everett, Wash.
Smith, L. B., Box 135, Talbotton, Ga.
Soliviev, L., Amtorg Trading Corp., New York, N. Y.
Sommerman, G. M., Johns Hopkins University, Baltimore, Md.
Soupos, B., Brooklyn Edison Co., Brooklyn, N. Y.
Sponsler, J. B., Lehigh University, Bethlehem, Pa.
Squire, E. M., Bell Telephone Laboratories, Inc., New York, N. Y.
Stauder, L. F., General Electric Co., Lynn, Mass.
Steen, H. N., University of Washington, Seattle, Wash.
Stemmler, G. J., American Tel. & Tel. Co., Denver, Colo.
St. Louis, J. A., General Electric Vapor Lamp Co., Hoboken, N. J.
Stroinski, B. C., Bucyrus-Erie Co., Cudahy, Wis.
Sutherland, J. R., General Electric Co., Schenectady, N. Y.
Sutton, M. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Swingle, R. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Tabor, H. S., New York Central Railroad, New York, N. Y.
Taylor, C. E., Peterson & Cowan Elevator Co., Ltd., Vancouver, B. C., Can.
Taylor, K. A., Bell Telephone Co. of Penna., Pittsburgh, Pa.
Thompson, C. W., New York Central Railroad, Tuckahoe, N. Y.
Thompson, L. M., (Member), Stone & Webster, Inc., Boston, Mass.
Thornton, L. A., (Member), Saskatchewan Power Comm., Regina, Sask., Can.
Tidd, W. H., American Tel. & Tel. Co., New York, N. Y.
Tidmore, W. E., Collinsville, Ala.
Traeger, W. H., (Member), General Cable Corp., St. Louis, Mo.
Treweek, J. E., Pennsylvania Power & Light Co., Hazleton, Pa.
Trump, J. G., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Urban, F. O., General Electric Co., Schenectady, N. Y.
Valentine, D. H., New Jersey Bell Tel. Co., Newark, N. J.
Van Zandt, J. G., U. S. Engineer Office, Pittsburgh, Pa.
Varga, G. E., Westinghouse Elec. & Mfg Co., Braddock, Pa.
Vaughan, H. R., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Ver Planck, D. W., General Electric Co., Schenectady, N. Y.
Vigness, C. I., University of Minnesota, Minneapolis, Minn.
Villavaso, J. M., Phoenix Utility Co. & Louisiana Pr. & Lt. Co., Algiers, La.
Walke, R. S., Stone & Webster Engg. Corp., Boston, Mass.
Walker, J. A., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Wallis, J., Okla. Gas & Electric Co., Oklahoma City, Okla.
Warner, S. E., Rensselaer Polytechnic Institute, Troy, N. Y.
Waterman, W., Radio Systems, Inc., New York, N. Y.
Wear, H. D., U. S. Lighthouse Service, Detroit, Mich.
Weinshank, L., Lewis Institute, Chicago, Ill.
Wiederhold, O., Atlantic Refining Co., Philadelphia, Pa.
(Applicant for re-election)
Williams, E. C., Canadian General Electric Co., Ltd., Peterboro, Ont., Can.
Williams, F. J., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Wilson, A. R., Amicable Life Insurance Co., Waco, Tex.
(Applicant for re-election.)
Winschuh, J. H., Public Service Elec. & Gas Co., Newark, N. J.
Wodicka, F. J., N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Wodrich, H. B., Westinghouse Electric Elevator Co., Chicago, Ill.
Wood, W. D., Southern Bell Tel. & Tel. Co., Louisville, Ky.
Woodward, W. B., Ohio Bell Telephone Co., Akron, Ohio
Wyckoff, L. E., 217 Vassar Ave., Newark, N. J.
Yenrick, K., Emerson Electric Mfg. Co., St. Louis, Mo.
Youel, V. H., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Young, E. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Zilberman, M. C., 1831 Marmion Ave., New York, N. Y.

Total 243

Foreign

Andersen, R. C., Electric Transmission Ltd., London, N. 1, Eng.
Condon, K. V., The Bolivian Power Co., Ltd., La Paz, Bolivia, South America
Kerr, A. N., Crompton Parkinson Ltd., London, Eng.
Lima, A. C., Brazilian Army Radio Service, Rio de Janeiro, Brazil, So. Amer.
Shah, J. P., Messrs, Desai Shah & Co., Kathiawar, India
Siddhu, H. S., Hydro Power Station, Simla, India
Throncroft, E. W., Council Chambers, Sutherland, N. S. W., Australia

Total 7

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National Secretary
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General Counsel: Parker & Aaron, 30 Broad Street, New York

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H. W. Flashman, Aus. Westinghouse Elec. Co. Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.
F. M. Servos, Rio de Janiero Tramways, Light & Power Co., Rio de Janeiro, Brazil.
A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.
A. S. Garfield, 173 Boulevard Haussmann, Paris 8 E., France.
Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. Chatelain, Lesnoi Polytechnic Institute, Apt. 27, Leningrad, U. S. S. R.
Axel F. Enstrom, 24a Ingeniorsvetenskrapsakademien, Stockholm, 5 Sweden.
W. Eldson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

A. I. E. E. COMMITTEES

(A list of the personnel of Institute committees may be found in the September issue of the Journal.)

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Engineering Profession, H. A. Kidder
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DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Coupling Capacitors.—Bulletin GEA-1261, 16 pp. Describes oil-filled, coupling capacitors for carrier-current applications. General Electric Company, Schenectady, N. Y.

Radio Test Equipment.—Circular, 6 pp. Describes Weston portable radio set testers for all types of a-c. and d-c. sets. Weston Electrical Instrument Corp., 584 Frelinghusen Ave., Newark, N. J.

Motor Starter.—Bulletin 4 pp. Describes the new EC&M 2300 volt motor starter, for full voltage starting of squirrel cage and synchronous motors, and for primary control of slip-ring motors. The Electric Controller & Mfg. Co., Cleveland, Ohio.

Centrifugal Pumping Units. Bulletin 1647, 16 pp. Describes Allis-Chalmers type "SSU" centrifugal pumping units. In these machines the pump and motor have been designed as a complete unit, no coupling being employed. Allis-Chalmers Manufacturing Co., Milwaukee.

Amplifying Equipment.—Catalog, describing Ferranti amplifying equipment for educational and commercial requirements, and standard and special audio-transformers now made in the U. S. A. Ferranti, Inc., 130 West 42nd St., New York.

Oil Circuit Breakers.—Bulletin GEA-959B, 8 pp. Describes type FKR-155 oil circuit breakers. This is a complete line of indoor breakers for modern and heavy-duty service at any latitude. Capacities 7500 and 15,000 volts, 400 to 3000 amperes, triple-pole, single-throw. General Electric Company, Schenectady, N. Y.

Ball Bearings.—Bulletin, 8 pp. Describes Norma-Hoffman "Greaseal" felt protected ball bearings. In these bearings the felt closure is an inherent part of the bearing itself. Previous to this development it was the conventional practise to provide closures or seals, separate and distinct from the bearing itself, involving the use of extra parts and attendant machining. Norma-Hoffmann Bearings Corp., Stamford, Conn.

Fastenings.—Booklet, 24 pp., entitled "Fastenings—How They Are Made By Leaders in the Metal Working Industries." The booklet consists of a series of condensed experiences of manufacturers, several electrical or allied, with Parker-Kalon hardened self-tapping screws. The comparative studies of alternate fastening methods on basic assembly problems should be helpful to engineers concerned with design, production or assembly. Parker-Kalon Corporation, 198 Varick Street, New York.

Westinghouse General Catalog.—Edition of 1931-1932, 1352 pages, presenting descriptions and illustrations of apparatus representative of products manufactured and sold by the Westinghouse Electric and Manufacturing Company, East Pittsburgh has been announced recently by that Company. This catalog presents complete listings of distribution apparatus, switchgear apparatus (except large oil circuit-breakers and power switchboards), lighting equipment, domestic appliances, gearing apparatus, and current-collecting devices; condensed listings of industrial motors and control apparatus, industrial heating apparatus, and commercial cooking equipment; and descriptions of other products.

NOTES OF THE INDUSTRY

Ward Leonard Electric Company Appoints R. C. James.—An announcement of the Ward Leonard Electric Company, Mount Vernon, N. Y., discloses the appointment of R. C. James in the Seattle district. Mr. James' organization will be located at 2321 Second Avenue, Seattle, Washington.

New Edison Storage Battery.—The Edison Storage Battery Company, of Orange, N. J., has recently announced the production of a storage battery of greater capacity than the present "A" type. The new battery is known as the "C" type. It has the same characteristics of long life, dependability and durability as the well known "A" type—but with a 50 per cent greater capacity without dimensional increase.

A New Motor Starter.—The Monitor Controller Company, Baltimore, Md., has devised an oil-immersed thermaload starter, —control equipment which gives across-the-line full voltage start with overload and low-voltage protection. This starter consists of a standard Monitor magnetic contactor mounted on a panel with a Monitor thermal relay and enclosed in an oil-tight box. This starter gives positive protection to polyphase and single-phase motors both while starting and while running. It permits a full-voltage, full-current and full-torque start and yet protects the motor from harmful overload. In addition to the usual overload protections, the Monitor oil-immersed thermaload starter will disconnect the motor if the voltage fails or drops excessively. It will prevent damage to polyphase motors from running single-phase, in case one of the phases goes dead, thus over-loading another phase.

E-M Synchronous Condensers Totaling 20,000 Kv-a. for Buick.—The installation of three synchronous condensers, totaling 20,000 kv-a. in plants of the Buick Motor Car Company at Flint, Michigan, will mark the largest power factor improvement undertaking made so far by an industrial plant, according to the Electric Machinery Manufacturing Company, of Minneapolis, with whom an order for these machines was recently placed by the Buick Motor Car Company of Detroit. It consists of one 10,000 kv-a., one 6000 kv-a., and one 4000 kv-a. condensers. Each condenser is equipped with a separate exciter, and a pilot exciter to obtain quicker response to line disturbances, and to enable the excitation to be brought up more quickly. The control to be supplied for each machine consists of a specialized form of reduced voltage automatic control.

C. W. Abbott Enters Advertising Business.—Charles W. Abbott, formerly director of low tension engineering, General Cable Corporation, has recently joined the advertising firm of Moser & Cotins, Brown & Lyon, Inc. Mr. Abbott becomes vice-president and will devote much of his activity to selling the services of his new organization. He has been identified with the electrical industry for more than twenty years as an engineer with central stations; as an officer of manufacturing companies; as an inventor of recognized and widely used material; as sales manager and buyer of advertising; as a member of committees of N. E. M. A., and other leading organizations. Moser & Cotins, Brown & Lyon, Inc. has offices in the Graybar Building, New York, and at 10 Hopper Street, Utica, N. Y. Mr. Abbott will be available for consultation at either address, but will make his headquarters at the New York office.

New Dollar Liner to be Launched.—The first electric passenger liner built in this country for trans-oceanic service will be launched at Newport News, Virginia, December 9, when Mrs. Herbert Hoover, wife of the president, will perform the christening. The new liner is to be named "The President Hoover" and is the first of two being built for the Dollar Steamship Line by the Newport News Shipbuilding and Dry Dock Company.

The two ships, each over 600 feet long, will be completely electrified, using the turbine-electric method of propulsion and using electricity for every other possible duty aboard ship, including lighting, the operation of auxiliaries and the use of electric heat for various purposes. The ships will be of twin-screw design and built for a speed of 20 knots. Accommodations will be provided for 450 passengers and a crew of more than 300. The power plant on the President Hoover will consist of two 11,000-shaft-horsepower General Electric turbines running at 2500 r. p. m. and driving two alternating-current G. E. generators each having a continuous rating of 10,100 kilowatts, 3 phase, 4800 volts. These generators will supply electricity for driving two 13,250-horsepower, synchronous-induction G. E. motors each connected to one of the two propeller shafts turning at the rate of 133 r. p. m.


From the Early Period
of the Telegraph to the present
remarkable development in the field of Electricity
KERITE
has been continuously demonstrating the
fact that it is the most reliable and
permanent insulation known
THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO SAN FRANCISCO

for MEASURING RESISTANCE and MAKING CONTINUITY TESTS

WESTON

To meet the growing demand for a low price portable ohmmeter for measuring circuit resistances and continuity, Weston now offers the double range Model 563 D. C. Circuit Tester. This new comer to the Weston line is accurate, compact, and rapid in operation. It is handsomely designed, thoroughly dependable, and built to withstand the hard service encountered in field service work.

The two ranges of the instrument 0-50,000 and 0-5000 ohms permit an unusually wide scope of measurements; thus this one instrument serves for practically all resistance testing usually encountered.

Model 563 is a high sensitivity instrument, hence the drain on the self-contained 1.5 volt dry cell is exceedingly slight—on the high range, only 1 milliampere and on the low range, 10 milliamperes. On the high range the life of the cell is therefore practically its "shelf" life and assures long service before necessity of replacement. Write for Circular LL which gives more detailed information about this new instrument and its many uses.

WESTON ELECTRICAL INSTRUMENT CORPORATION
584 Frelinghuysen Avenue, Newark, N. J.



MODEL 563
D. C. Circuit Tester
(Actual Size)

DESCRIPTION OF MODEL 563

Model 563 contains a standard high resistance Model 301 3¼" diameter meter and has two ranges of 5,000 and 50,000 ohms, *two binding posts, a toggle switch for range selection,* and a pair of 30 inch cables. A voltage adjuster on top of the instrument provides an easy means to compensate for any changes in potential of the *self-contained* 1.5 flashlight battery cell. The complete instrument weighs only two pounds.

A SPECIALIST

in our midst

who manufactures transformers of the highest quality for every industrial, laboratory, and radio application . . . if desired, to your exact specifications.

- Small air-cooled transformers for industrial lighting and power—available from stock.
- Transformers for the Cottrell precipitation process—a type for installations of any size.
- High-voltage testing transformers for insulation manufacturers and utility companies.
- Small testing sets and transformers for electrical appliance manufacturers.
- High-current transformers for electric welding and electric-furnace installations.
- Power transformers for broadcasting, commercial, and amateur radio stations.
- Electric spot welding machines in sizes from 0.5 to 10 kilowatt.
- Audio-frequency transformers and complete amplifier systems for every requirement.

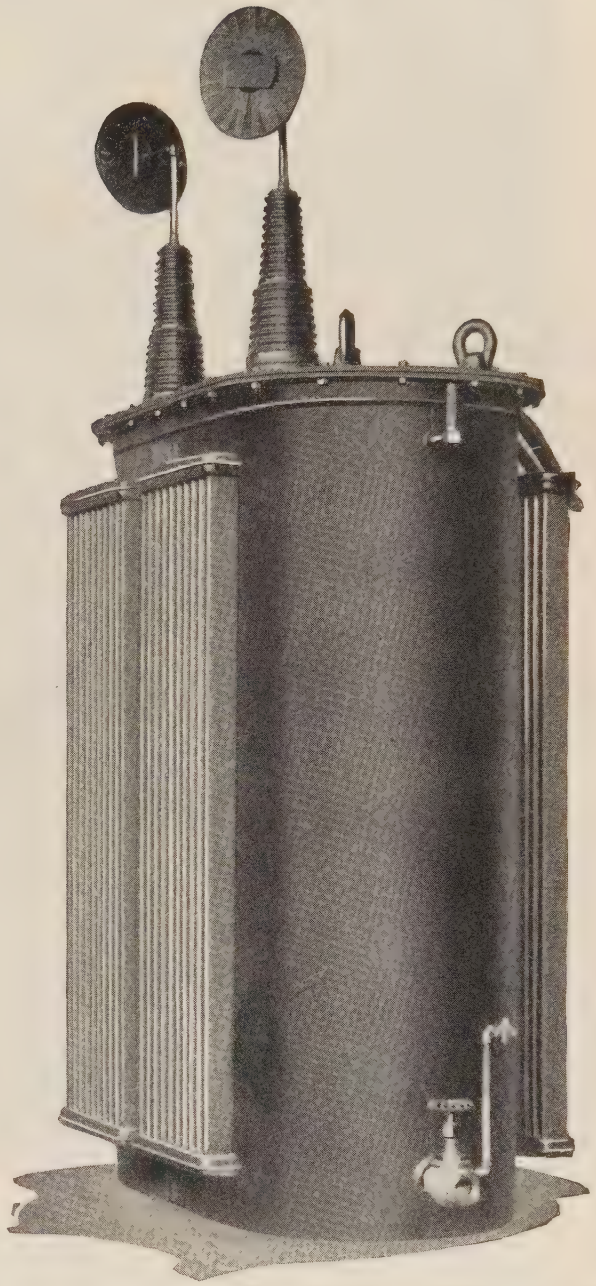
AMERICAN TRANSFORMER COMPANY

Transformer Builders for Over 29 Years

180 EMMET STREET **NEWARK, N. J.**

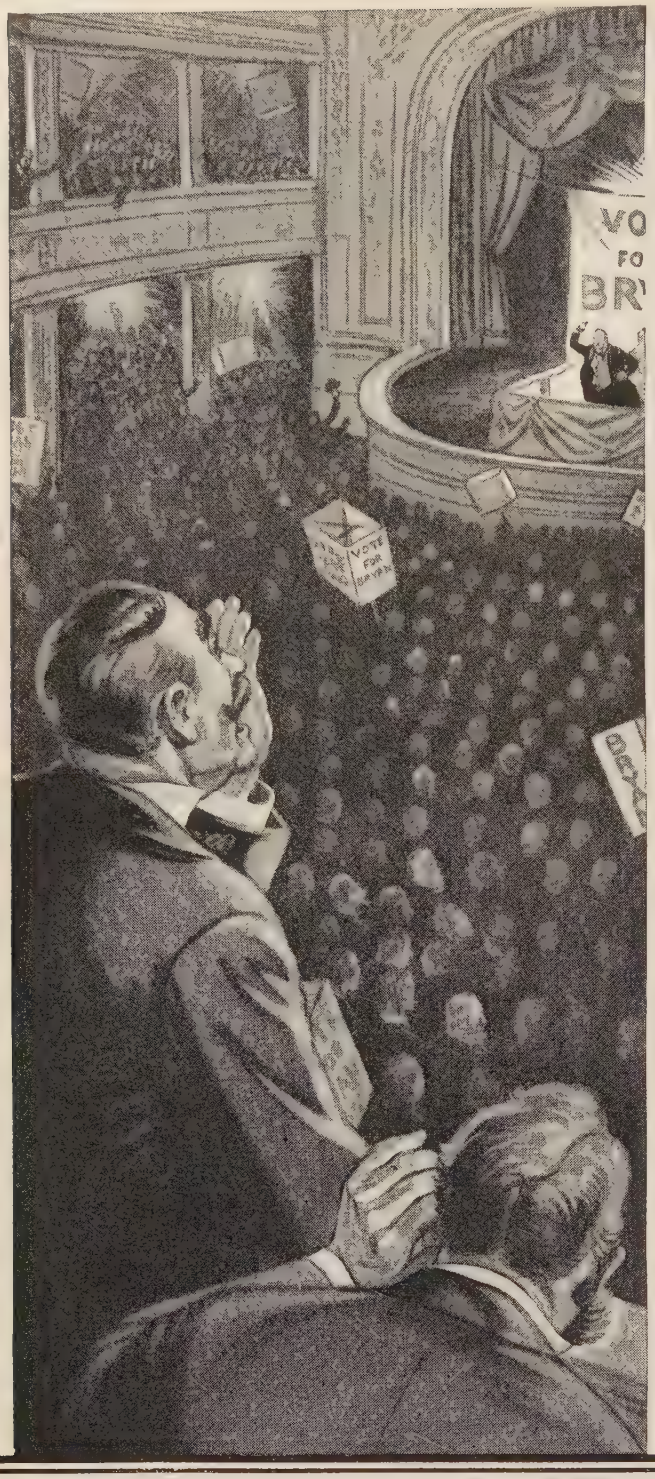
Representatives

Atlanta, Ga.—H. Douglas Stier, 101 Marietta St.
Boston, Mass.—Electrical Apparatus Sales Co., 10 High St.
Chicago, Ill.—Westburg Engineering Co., 53 West Jackson Blvd.
Knoxville, Tenn.—Arthur L. Pollard, 910 West Clinch Ave.
Minneapolis, Minn.—Elliott Equipment Co., 708 Sixth Ave., South.
Philadelphia, Pa.—L. D. Joralemon, 112 So. 16th St.
San Francisco, Calif.—James H. Southard, 682 Mission St.
St. Louis, Mo.—J. W. Jones, 432 Pennant Bldg.
Montreal, Que.—W. O. Taylor & Co., 415 Canada Cement Bldg.



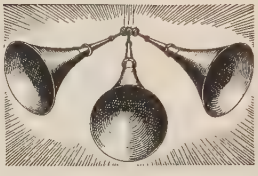
This high-voltage transformer was built specially for testing vacuum tubes used in transoceanic radio telephone service. It is rated at 385 kva. for continuous service and develops 100,000 volts.

AMERTRAN TRANSFORMERS



"Louder... louder!"

--- a cry of the past—



Straining forward to hear the speaker they were all ears and he was all lungs—but still they couldn't understand him. No wonder "louder please"—and remarks less courteous—were bywords at old time gatherings.

That was before Western Electric showed the world how to amplify and distribute the voice. Today the Western Electric Public Address System brings every word of the speaker to you, even in the last row of the balcony or on the far edge of the largest crowd outdoors.

And this, like most achievements in voice reproduction, was made possible only by this organization's long experience in making Bell telephones.

Western Electric

Makers of your Bell telephone and leaders in the development of sound transmission



For easy hearing, the Western Electric Public Address System makes every seat a front seat.

MASTER PORTABLES

A Remarkable Line of Rugged Instruments

JEWELL

with a meter for every test

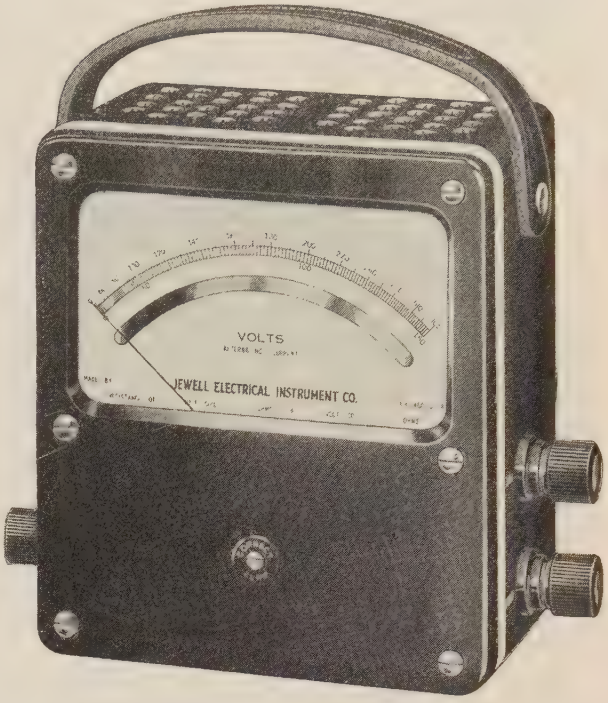
Do you use portable testing instruments?

If you do, consider carefully these advantages of Jewell Master Instruments.

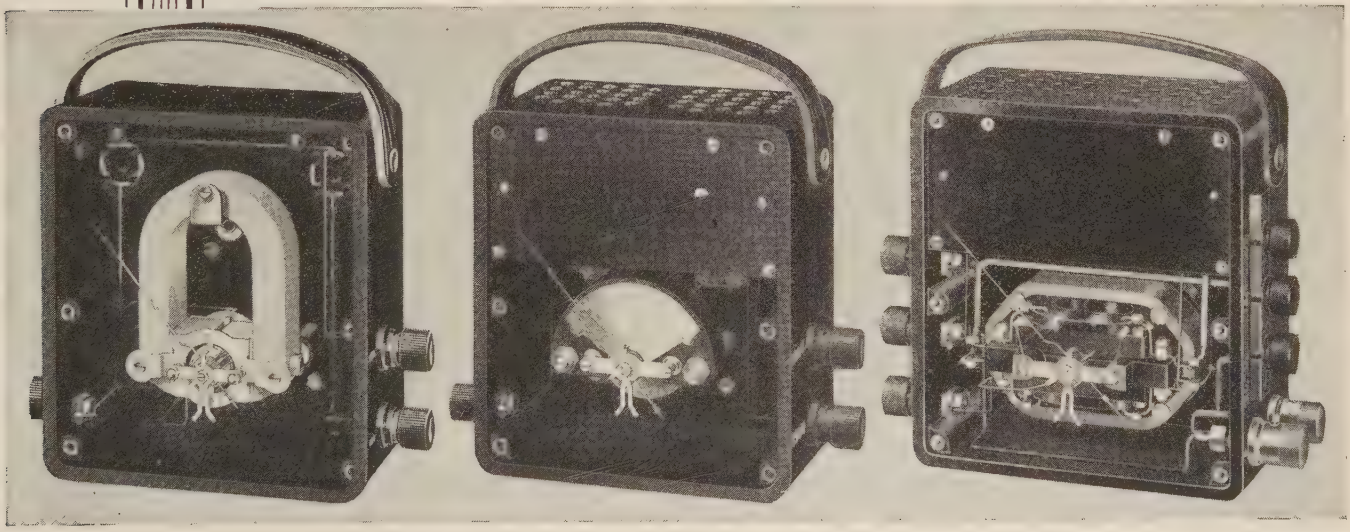
1. *All instruments are furnished in bakelite cases of uniform dimensions.*
2. *Large scale openings are enclosed with non-shatterable glass.*
3. *Movements are famous for accuracy and ability to withstand hardships of portable testing service.*

The Master Line includes Voltmeters, Ammeters, Wattmeters, Thermal Voltmeters, and VoltAmpWattmeters for alternating and direct current. There is a meter for every test. Send for descriptive bulletin.

Jewell Electrical Instrument Co.
1650 Walnut Street Chicago, Ill.



The remarkably large scale opening, enclosed with non-shatterable glass, makes the Master Instrument easy to read.



For direct current voltmeters and ammeters, the Jewell Style G Permanent Magnet Movement is used. The mechanical assembly is rigid, assuring stability of calibration. The rapid action and high damping speeds up all test jobs.

For alternating current voltmeters and ammeters, the Jewell Style D Iron Vane Movement is used. The damping chamber is of molded bakelite and highly efficient. The iron vane is riveted to the shaft to assure a permanent assembly.

For single and polyphase wattmeters, the Jewell Style L Dynamometer Movement is used. The vane box, supporting pillars, coil supports, and covers are of molded bakelite. The magnetic shield protects the instruments against external fields.

30 YEARS MAKING GOOD INSTRUMENTS

JEWELL

MASTER INSTRUMENTS



Aerial, underground, submarine—every type of power cable, for transmission or distribution circuits. Exceptional facilities in plants, men and experience are behind the splendid year-in year-out performance of Safety Power Cables. Expert engineering cooperation is always extended, gladly.

GENERAL CABLE CORPORATION

EXECUTIVE OFFICES: 420 LEXINGTON AVENUE, NEW YORK • OFFICES IN PRINCIPAL CITIES

ANNOUNCING

ALECTRAL

INSULATED ALUMINUM
WIRES AND CABLES AND
NECESSARY FITTINGS

GENERAL CABLE CORPORATION
ALUMINUM COMPANY OF AMERICA



THE INDUSTRY WILL REAP THE BENEFITS

ALCOA ALUMINUM was first used by the electrical industry in the form of transmission wire in 1898. Since that date the inherent advantages of this metal have carried it into the systems of practically every central station in the country and into the lines of many industrial corporations. To the original transmission line cable have been added conductors suitable for secondary circuits, telephone and signal lines, bus bars and many others.

Practically all of this development has been with bare conductors. Insulated aluminum conductors, with the exception of weatherproof wires, have not been available commercially.

Aluminum Company of America has welcomed the efforts of General Cable Corporation to develop a group of insulated wires and cables which could be made from ALCOA ALUMINUM. To the initial work of General Cable Corporation have been added the cooperative efforts of the Aluminum Company of America's Research staff. The resulting group of insulated aluminum conductors, while broad in scope, should be but the beginning of a steadily growing conductor classification of value to the entire electrical industry.

ALUMINUM COMPANY of AMERICA

ALECTRAL



A new group of insulated wires and cables with aluminum conductors • An important addition to General Cable's present broad coverage of various conductor materials • A major development from which the whole electrical industry will profit.

GENERAL CABLE CORPORATIO

AN HISTORIC ANNOUNCEMENT

GENERAL CABLE presents today a varied group of insulated aluminum wires and cables to be marketed under the trade name ALECTRAL.

This announcement is the culmination of a long period of cooperative study by the Research, Engineering and Manufacturing departments of General Cable Corporation and Aluminum Company of America.

Our study was begun in the belief that the favorable characteristics of aluminum had not heretofore been given due consideration by the industry.

Our conclusions are that in many fields of application, insulated aluminum conductors have definite economic or engineering advantages over existing conductor materials.

The use of insulated aluminum conductors has not heretofore been common, largely because there has been no completely prepared source of supply, no readily available engineering information, and no practically developed technique of use.

In announcing ALECTRAL wires and cables as a major group in our broad scope of products, we recognize the favorable characteristics of aluminum and will henceforward recommend its adoption in the many applications where its physical and electrical properties, its advantageous behavior in actual use, or its cost advantages, point to its specific superiority.

We are prepared to present the same high standard of engineering assistance in connection with its application, that General Cable Engineers have rendered on other types of conductors. The addition of ALECTRAL wires and cables to what was already the broadest group of conductor materials in the industry, including Copper, Copperweld, and Phono bronzes, makes the recommendations of our engineers uniquely unprejudiced.

It is our belief that the introduction of ALECTRAL wires and cables constitutes the most important basic step taken by a wire and cable manufacturer for the broad advancement of the industry. Although this announcement embraces a varied group of constructions, important additions will be announced from time to time as a result of active research which is being carried on in several interesting directions.

A L E C

ALECTRAL
INSULATED ALUMINUM
WIRES AND CABLES

THE initial group of ALECTRAL wires and cables described on succeeding pages includes certain representative constructions where advantages in cost, in weight, in strength per unit weight, or in the behavior of the conductor under load, promise that the adoption of ALECTRAL will be advantageous to the user.

For applications where tensile strength is not a prime consideration, the conductors of ALECTRAL wires and cables are all-aluminum.

For aerial service, where tensile strength in relation to resultant loads is of major importance, we have developed for ALECTRAL certain unique stranding combinations of aluminum and steel which will show favorable installed costs in both rural and urban distribution systems.

ALECTRAL wires and cables are materially lighter than the equivalent insulated copper conductors. In all classes of service where a saving in cable weight is desirable, such as in all forms of transportation, and on other moving equipment and parts, the lightness and reasonable cost of ALECTRAL wires and cables recommend their adoption.

A desirable property of ALECTRAL cables is the ability to burn clear under dead-short-circuit conditions far more quickly than conductors in common use. The advantage of this behavior in underground network systems is obvious.

Another important feature of ALECTRAL cables is that they run cooler under a given load. Since a larger conductor cross section results in greater heat radiation, ALECTRAL cables assure lower operating temperatures.

Efficient and economical splicing devices and technique have been developed, and we are offering certain basic devices and accessories designed specially for use with ALECTRAL wires and cables.

Our engineers will be glad to discuss with you the possibilities of applying ALECTRAL wires and cables to your individual requirements.

• • •

The words "Alectral," "Barkhide" and "Trenchlay" are trademarks of General Cable Corporation, and the many novel forms of insulated conductors, fittings and accessories resulting from our research and development, will be the subject of patent protection.

T R A L

A L E C T R A L

INSULATED LINE WIRE—Strength-resultant-load ratios equivalent to copper for urban use. Higher strengths for rural lines. Weatherproof jacket with voltage guarantee.

INSULATED LINE WIRE

TREEWIRE

TREE WIRE—The famous Barkhide abrasion protection over rubber insulated steel and aluminum conductors. The perfect combination with ALECTRAL Insulated Line Wire.

NON-METALLIC UNDERGROUND CABLE—All-aluminum conductor with standard Trenchlay insulation and non-metallic protective sheath. Extremely light and economical to install.

NON-METALLIC UNDERGROUND CABLE

MAGNET WIRE

MAGNET WIRE—Enameled, cotton covered, silk covered, or in combination. Weight of coil is materially reduced. Practically complete range of sizes.

STARTER CABLE—Stranded all-aluminum conductors with standard or special insulation. Flexible, non-corrosive. Less weight per car. Lower cost.

STARTER CABLE

GENERAL CABLE CORPORATION, 420 LEXINGTON AVE., NEW YORK

A L E C

A L E C T R A L

NETWORK CABLE

NETWORK CABLE — All-aluminum conductors, specification insulation. Extremely advantageous burn-off characteristics. Considerably lighter in weight.

CAR WIRING CABLE

CAR WIRING CABLE — All-aluminum conductors, specification insulation. Inherent reduction in weight is advantageous in all transportation applications.

ARMORED CABLES

ARMORED CABLES — Aluminum alloy in the form of flat strip, interlocking strip, and basket weave. Strong, non-corrosive, non-magnetic, light in weight.

FITTINGS

FITTINGS — Basic connection principles and technique have been developed together with simple fool-proof connectors and devices for their application.

OTHER WIRES AND CABLES

OTHER WIRES AND CABLES — These constructions are indicative of the possibilities of aluminum. Other ALECTRAL products will be announced, as they are perfected for practical use.

GENERAL CABLE CORPORATION, 420 LEXINGTON AVE., NEW YORK

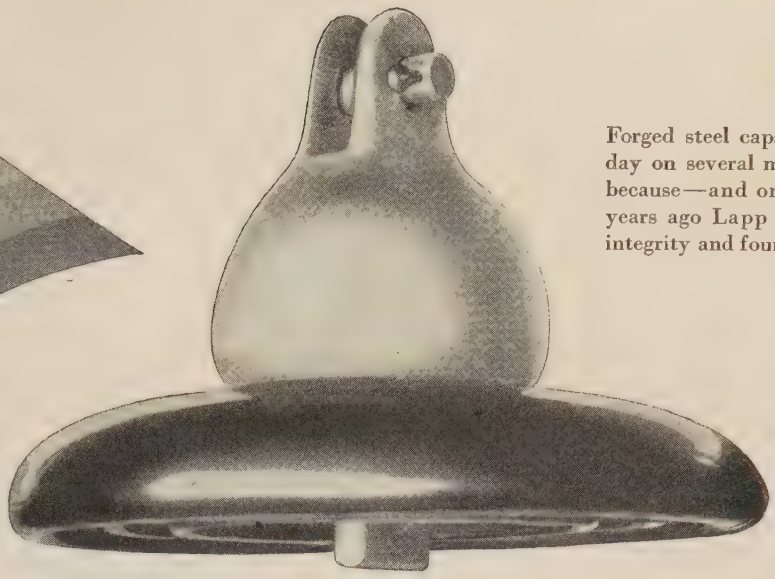
T R A L

ANNOUNCING

ALECTRAL

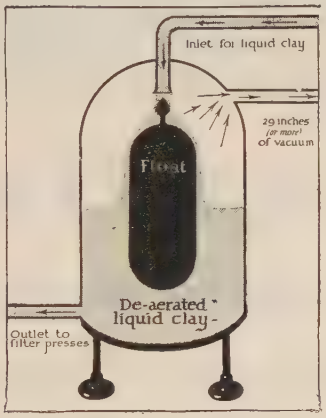
INSULATED ALUMINUM
WIRES AND CABLES AND
NECESSARY FITTINGS

ENERAL CABLE CORPORATION
LUMINUM COMPANY OF AMERICA



Forged steel caps are available today on several makes of insulators because—and only because—ten years ago Lapp demanded utmost integrity and found it in steel.

Insulator No. 6294



Mechanical and Dielectric faults in porcelain are usually due to air previously occluded in the liquid clay. The Vacuum Process removes the air and (naturally) the troubles due to occluded air.

Another Reason Why LAPP INSULATORS Cost More to Make

YES, even with manufacturing equipment that is not excelled anywhere for efficiency, every Lapp Insulator still costs us a premium to produce.

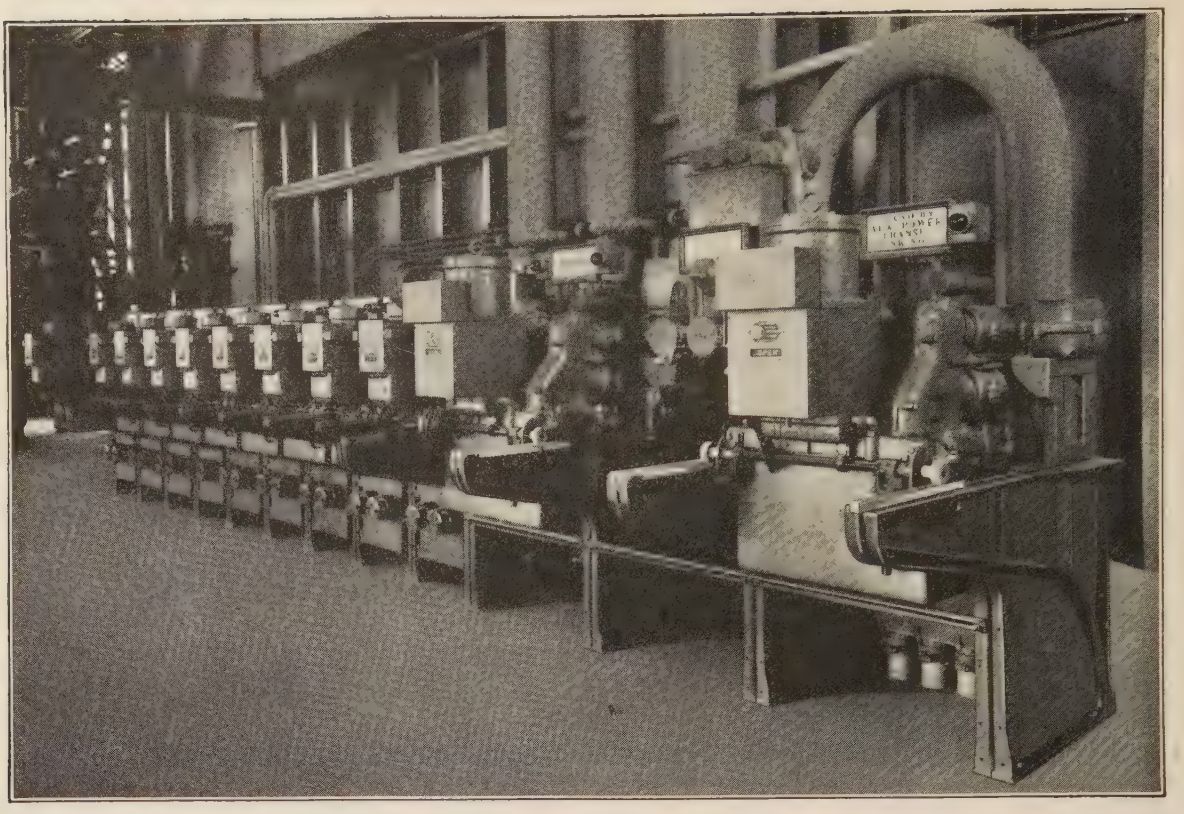
ONE reason—the copper-bearing forged steel cap. Lapp originated the forged cap idea, invested thousands of dollars to put it through. Now, one by one, other insulator makers are adopting the idea. But reluctant acceptance is not enthusiastic development.

THEN there's the Lapp Over-Potential Test —112 Kilovolts test instead of 90. And Rounded Contours that require special handling. And the Vacuum Process—providing additional security.

MORE costly to produce—more enduring on the job—but they cost you no more.

LAPP INSULATORS

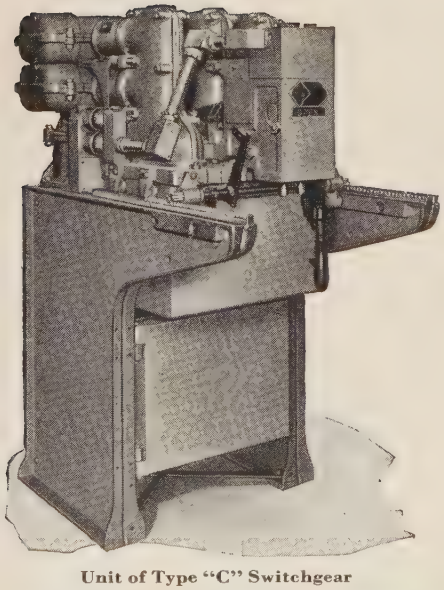
LAPP INSULATOR CO. INC. LEROY N.Y. U.S.A.



Nine 400 ampere type C and three 1300 ampere type B, 7500 volt switchgear units — part of the Armorclad Switchgear installed in a large power house.

Important Circuits

in large Power Houses served by *Armorclad Switchgear*



Unit of Type "C" Switchgear

In the selection of equipment for large powerhouses, every precaution is taken to insure efficient and reliable service. Outages from failures of main and auxiliary switching equipment cannot be tolerated as power users demand continuous service and power companies cannot afford to lose the revenue return.

The oil circuit breaker equipment occupies a position preeminent in insuring efficient and reliable service in the power house as it provides the means for controlling the distribution of electrical energy for the main and auxiliary circuits. Allis-Chalmers Armorclad Switchgear is inherently of very rugged construction. Its complete system of interlocks and easy observation of switch position practically eliminates mistakes in operation.

Armorclad Switchgear is built in a number of sizes to cover a complete line of oil circuit breaker equipment. You cannot afford to overlook its possibilities when considering a new oil circuit breaker installation.

Armorclad Switchgear is described in Bulletin 1145-A, a copy of which may be obtained from any Allis-Chalmers Sales Office.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee



Greetings

from

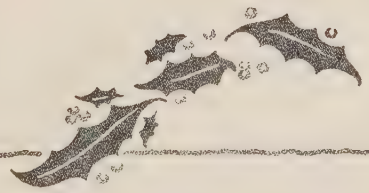
American Steel & Wire Company

Again the Yuletide, with its inspirations of good cheer is with us—the New Year approaches—and we sincerely extend to you our very best wishes for a very

MERRY CHRISTMAS and a
HAPPY, PROSPEROUS
NINETEEN THIRTY-ONE

ELECTRICAL WIRES
Manufactured by
AMERICAN STEEL & WIRE COMPANY

Rubber Covered
Weatherproof
Bare Copper—Magnet
Annunciator and Office Wires
Lamp Cords—Trolley Wire
Automobile Cables
Submarine Cables
Park and Suburban Cables
Power Cables
Either Rubber, Cambric or Paper Insulated



American Steel & Wire Company

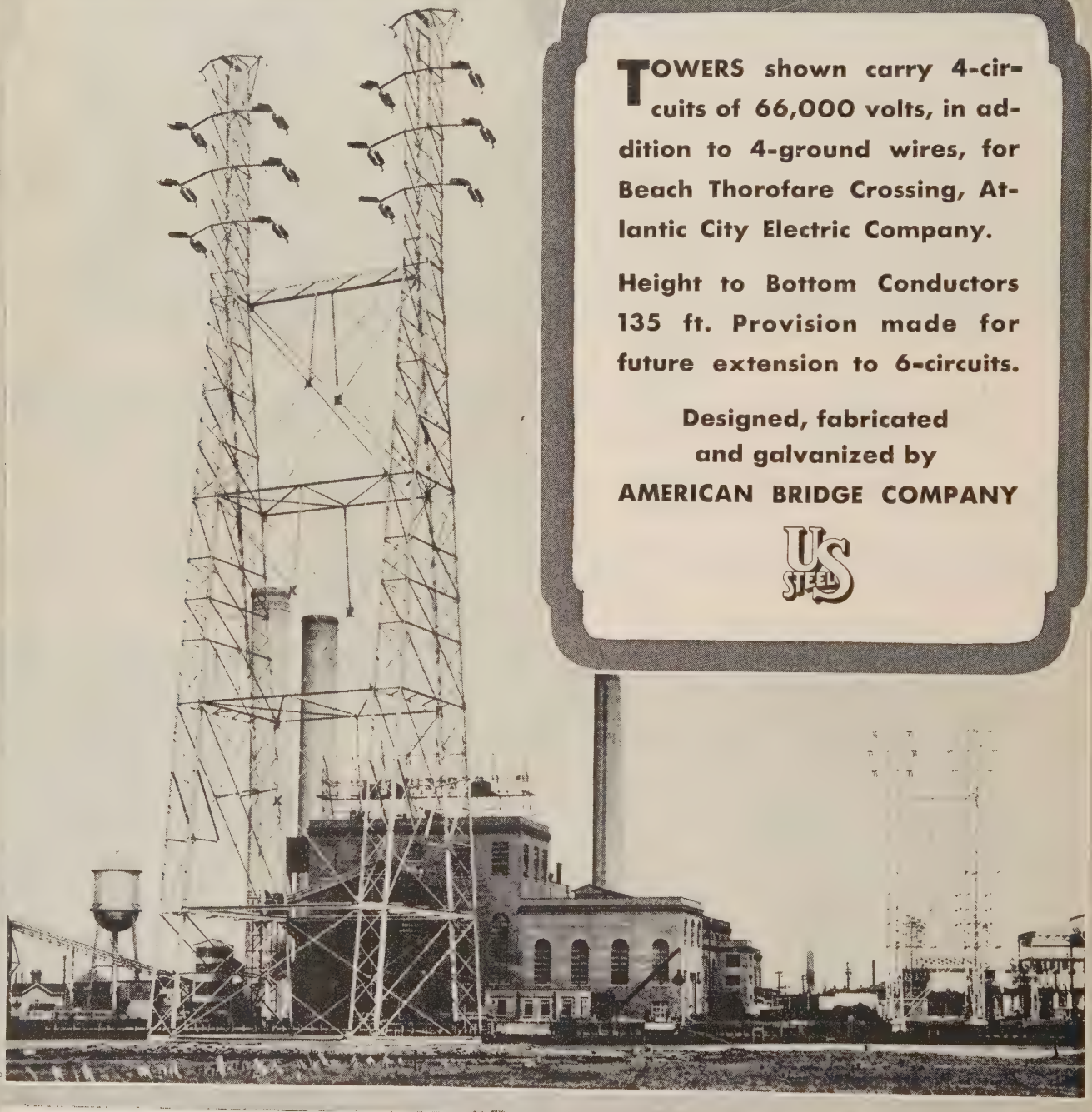
SUBSIDIARY OF UNITED STATES STEEL CORPORATION

208 S. La Salle Street, Chicago — 30 Church Street, New York

Other Sales Offices: Atlanta, Baltimore, Birmingham, Boston, Buffalo, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Memphis, Milwaukee, Minneapolis-St. Paul, Oklahoma City, Philadelphia, Pittsburgh, Salt Lake City, St. Louis, Wilkes-Barre, Worcester

Pacific Coast Distributors: Columbia Steel Company, San Francisco, Los Angeles, Portland, Seattle, Honolulu
Export Distributors: United States Steel Products Co., 30 Church St., New York City

ABCo TRANSMISSION TOWERS



TOWERS shown carry 4-circuits of 66,000 volts, in addition to 4-ground wires, for Beach Thorofare Crossing, Atlantic City Electric Company.

Height to Bottom Conductors 135 ft. Provision made for future extension to 6-circuits.

Designed, fabricated and galvanized by
AMERICAN BRIDGE COMPANY

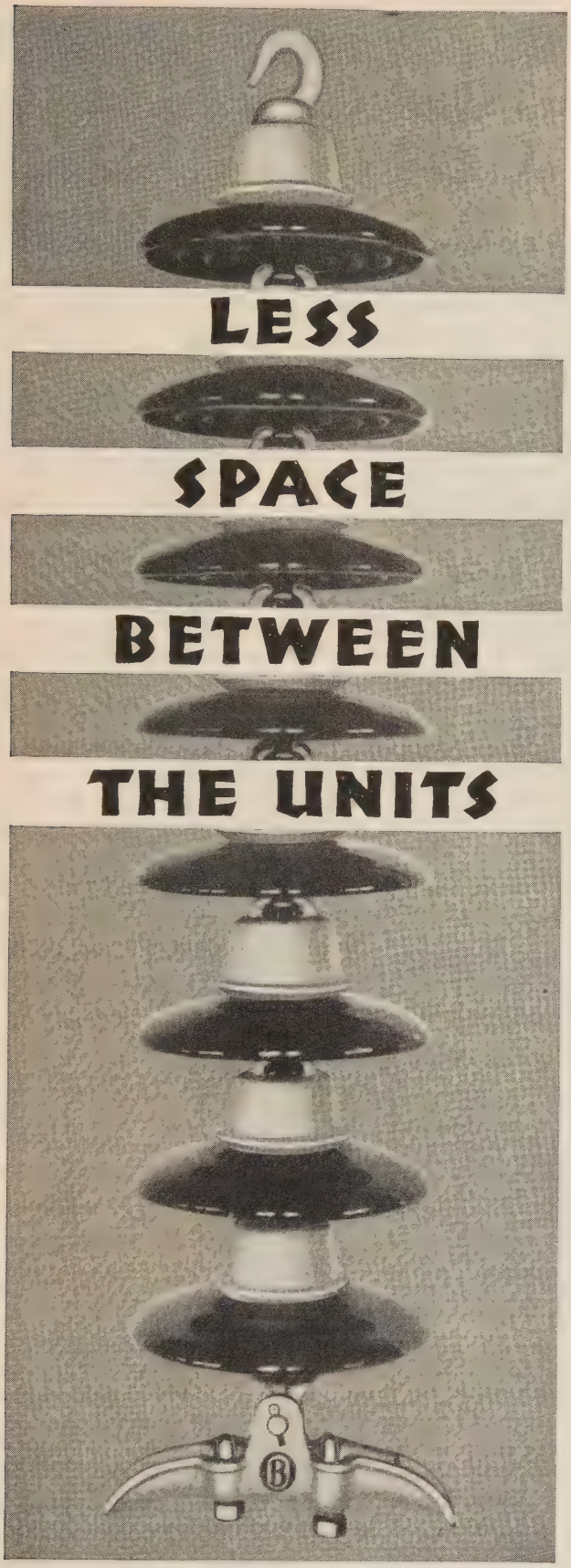
US STEEL

AMERICAN BRIDGE COMPANY

Subsidiary of United States Steel Corporation

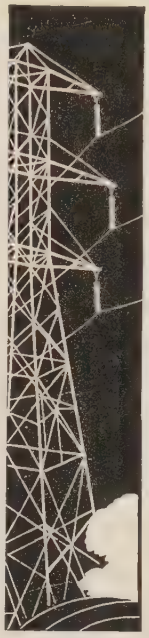
General Offices - 71 Broadway, New York City

Tower Department, Frick Building, Pittsburgh, Pa.





1. Tell-Tale Color Glaze
2. Short Spaced Units
3. The Gasket Assembly
4. The Beaded Cap Design
5. The Sanded Surface
6. Treated Sanded Surface Joints
7. The Resilient Steel Pin



WET AND DRY flashover values have always been governing factors in determining the length of a string of suspension insulator units.

But, the distance between the units is highly important in controlling the performance of the string. Obviously, free arcing is most desirable. A suspension insulator unit, which improves the free arcing characteristics of the insulator string, provides an appreciably higher electrical factor of safety.

The investigations of O-B engineers into this problem brought about the development in 1911 of a shorter-spaced unit, the predecessor of the present O-B No. 25622.

Reducing the spacing between the units in an insulator string materially increases the air path ratio of the string. Too, the percentage of porcelain in a string of given length is correspondingly increased. This increase of the dielectric—by "packing" more insulation into the string—greatly reduces the operating hazard by increasing the tested factor of safety.

Again, any increase in the number of units in a given string length reduces the electrical stresses within the individual insulator unit, and at the same time increases the leakage resistance of the string.

Coincidentally, in accomplishing this greater value of the insulator, there was developed an equally important result. Insulator string length is an important and governing factor in tower design. With the short-spaced unit it is possible to employ an insulator string of greater electrical value without increasing tower clearances or costs.

Short-spaced units have by performance in the field of practical use, paid their way into the classification of one of the Seven Keys to Value.

Ohio Brass Company, Mansfield, Ohio
Canadian Ohio Brass Company, Limited
Niagara Falls, Canada
1306H

Ohio Brass Co.

NEW YORK PITTSBURGH CHICAGO CLEVELAND ST. LOUIS ATLANTA DALLAS
PHILADELPHIA BOSTON LOS ANGELES SAN FRANCISCO SEATTLE

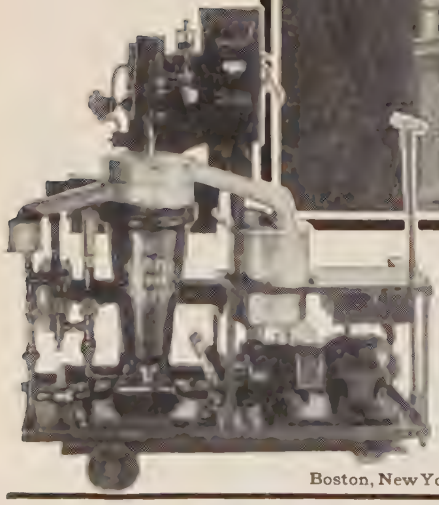
PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

PHILADELPHIA'S FINEST OFFICE BUILDING USES THE WORLD'S MOST EFFICIENT OIL PURIFIER



FIDELITY-PHILADELPHIA TRUST COMPANY

Photo by R. T. Dooner



PHILADELPHIA's most modern office building—the Fidelity-Philadelphia Trust Company—protects its electrical equipment by the use of Sharples-purified transformer oil. In this great building are installed 18 G. E. transformers of 250 K. V. A., 12 of 100 K. V. A., and 2 Voltage regulators of 288 K. V. A. The 6000 gallons of oil used in these transformers are kept clean and safe—at a dielectric strength above 32,000 volts—by a Sharples Portable Purifier.

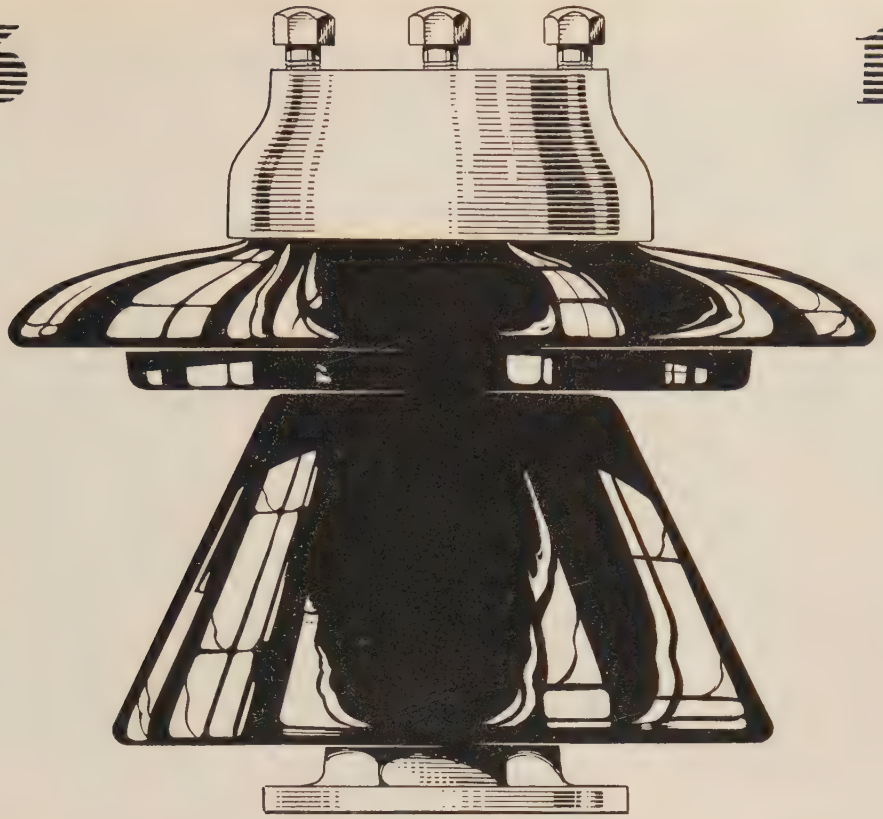
Sharples units can always be counted on to give *high dielectrics* at *high capacity*.

THE SHARPLES SPECIALTY COMPANY, 2324 WESTMORELAND STREET, PHILADELPHIA.
Boston, New York, Pittsburgh, Chicago, Detroit, Tulsa, San Francisco, Los Angeles, Toronto. Factories in England and France.

SHARPLES

CENTRIFUGAL ENGINEERS • • PHILADELPHIA

1893



1930

PERFORMANCE IS THE ONLY MEASURE OF QUALITY

QUALITY is only too frequently misunderstood even by those who talk most about it. No addition—no refinement is truly an indication of the quality of the product unless such refinements are reflected in increased satisfaction and improved performance.

In an insulator, as in all else, these are the only true guides by which quality may be determined. Highsounding processes and erudite theories are valueless unless they mean better service.

The reputation which Locke Insulators have won is based solely on the record for satisfactory service which they have established in the field for thirty-seven years.

That's quality.

LOCKE PORCELAIN INSULATORS

LOCKE INSULATOR CORPORATION • • BALTIMORE, MARYLAND



Their words have wings as swift as light

An Advertisement of the American Telephone and Telegraph Company

We live and work as no other people have ever done. Our activities are pitched to the swiftness of the instantaneous age.

Whatever happens, wherever it happens and however it may affect you, you may know it immediately over the wires or the channels of the air that carry men's words with the speed of light. Business and social life are free from the restrictions of time and distance—for practically any one, anywhere, may at any time speak with any one, anywhere else.

The widespread and co-ordinated interests of the nation depend upon an intercourse that less than sixty years ago was not possible in a single community. This is the task of the telephone wires and cables of the Bell Telephone System—to make a single community of our vast, busy continent wherein a man in Los Angeles may talk with another in Baltimore or a friend in Europe as readily as with his neighbor.

It is the work of the Bell Telephone System to enable friends, families and business associates to speak clearly and immediately with one another, wherever they may be. Its service is as helpful and accessible on a village street as in the largest cities.

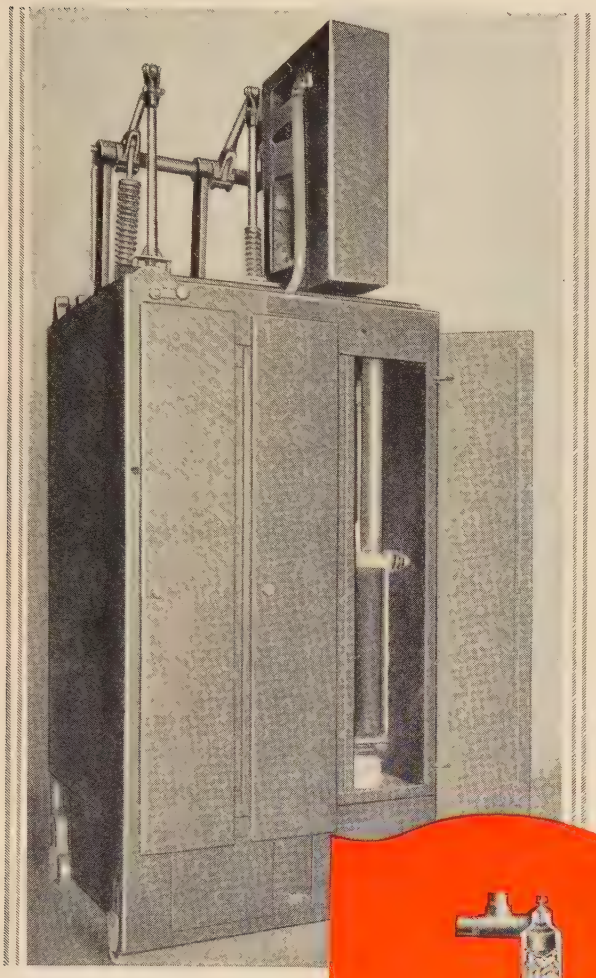
To match the growing sweep and complexity of life in this country, to prepare the way for new accomplishments, the Bell System is constantly adding to its equipment and bettering its service.

To this end, its construction program for 1930 has been the largest in its history. This System at all times accepts its responsibility to forward the development and well-being of the nation.

AMERICAN TELEPHONE & TELEGRAPH CO AND ASSOCIATED COMPANIES
BELL SYSTEM

[EXPLOSION-CHAMBER OIL CIRCUIT BREAKERS]

Added to the Type FH Breakers A Trip-free Motor Mechanism





Cross section view of explosion chamber

SO POPULAR is the Type FH line of oil circuit breakers that nearly 30,000 have been installed — some purchasers using as many as 1000. The most recent improvement in these breakers is the addition of a trip-free motor mechanism.

Consider only the major improvements which have been made:

1898 — First FH breaker manufactured

1903 — Explosion-chamber principle applied

1913 — Tanks made easily removable

1918 — Adapted to truck mounting

1919 — Separating chamber added, together with features that prevent oil throwing

1930 — Trip-free motor mechanism added

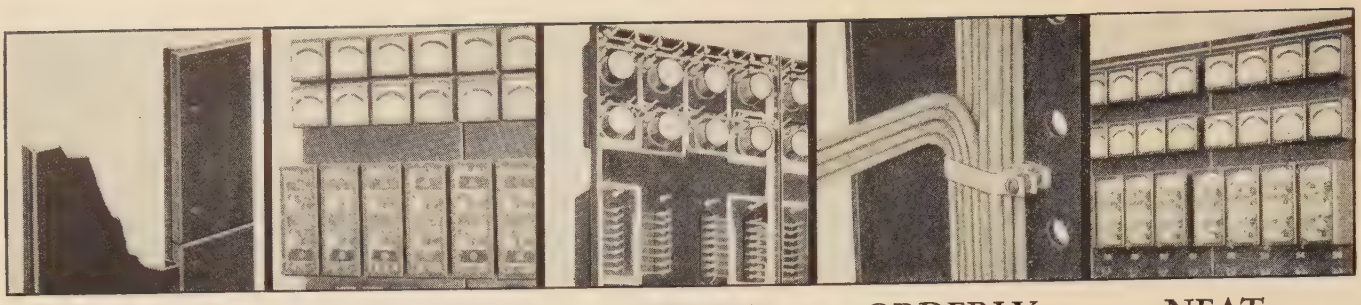
Type FH breakers are performing to-day in the same satisfactory manner as when first installed — over 30 years ago. The Type FH are particularly favored by operating engineers because these years of successful performance have proved their rated interrupting ability. They were the first oil circuit breakers to use the explosion-chamber principle.

470-20

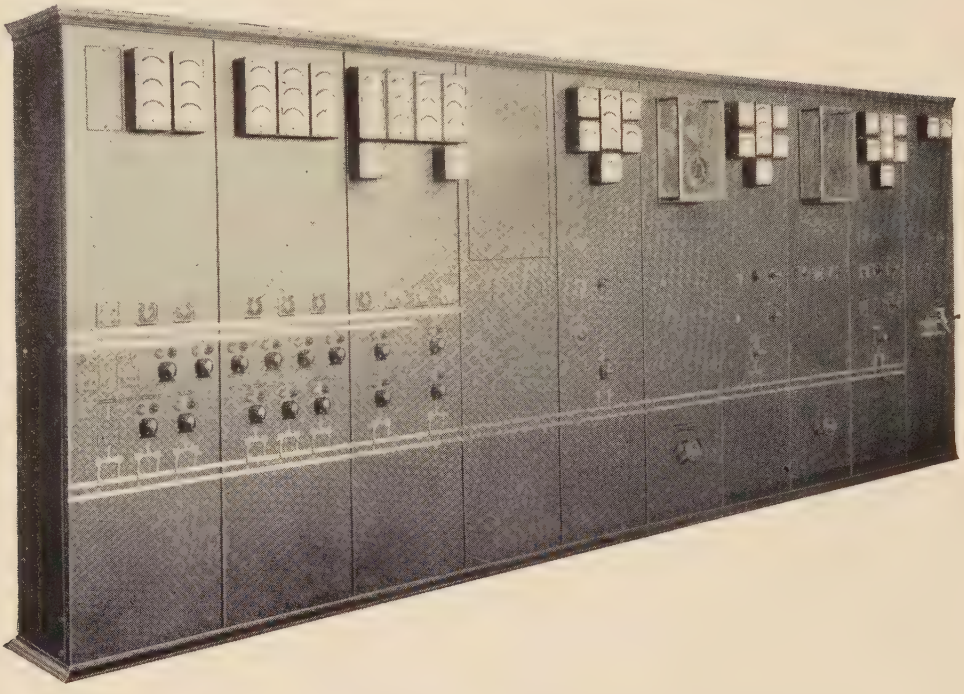
JOIN US IN THE GENERAL ELECTRIC PROGRAM, BROADCAST EVERY SATURDAY EVENING ON A NATION-WIDE N.B.C. NETWORK

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES



STRONG COMPACT ACCESSIBLE ORDERLY NEAT



Switchboards of Steel

General Electric engineers have taken advantage of the fact that steel is easy to cut, to trim, to erect, and to punch for the mounting of panel devices. They have built into G-E steel-panel switchboards just the features you would like to have.

The use of $\frac{5}{32}$-inch stretcher-leveled steel with crimped edges gives the needed strength and lasting qualities. No substance more readily lends itself to an orderly, compact arrangement of devices. And you have but to see the back of a G-E steel panel to appreciate how neatly and how accessibly panel wiring can be arranged.

G-E steel-panel switchboards can be furnished in vertical, self-contained, hinged-panel, and benchboard styles. Which type meets your requirements? Printed information or the services of a switchgear specialist are available through the nearest G-E office.

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

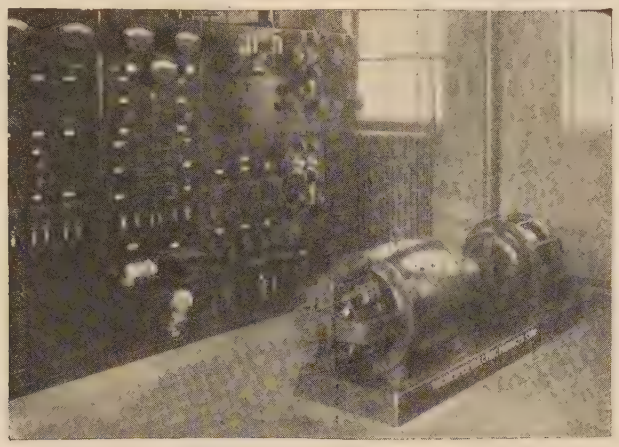
SHUNT WOUND BATTERY CHARGER

THE DIVERTER POLE GENERATOR

CONSTANT VOLTAGE INHERENT — RUNS AS MOTOR SAFELY

THE ELECTRIC PRODUCTS COMPANY · PATENTED · JAN. 1926 · CLEVELAND, OHIO, U.S.A.

FOR ALL KINDS OF BATTERY CHARGING—WITH SAFETY & ECONOMY



One of the 10 Kw. Diverter Pole Generator Sets installed by the General Railway Signal Co. for the Michigan Central Railroad

THE above illustration is a good example of the safety and simplicity of Diverter Pole generator installations.

The Diverter Pole Generator normally driven by a synchronous motor is permanently connected across a 120 cell storage battery and carries all the D. C. load.

In case of power interruption the generator functions as a motor and the synchronous motor as a generator and supplies current for the A. C. equipment.

The installation is unattended except for periodic inspection and cleaning. An allied company plans to duplicate this installation this coming year.

We will gladly send, upon request, a copy of our new Bulletin giving details.

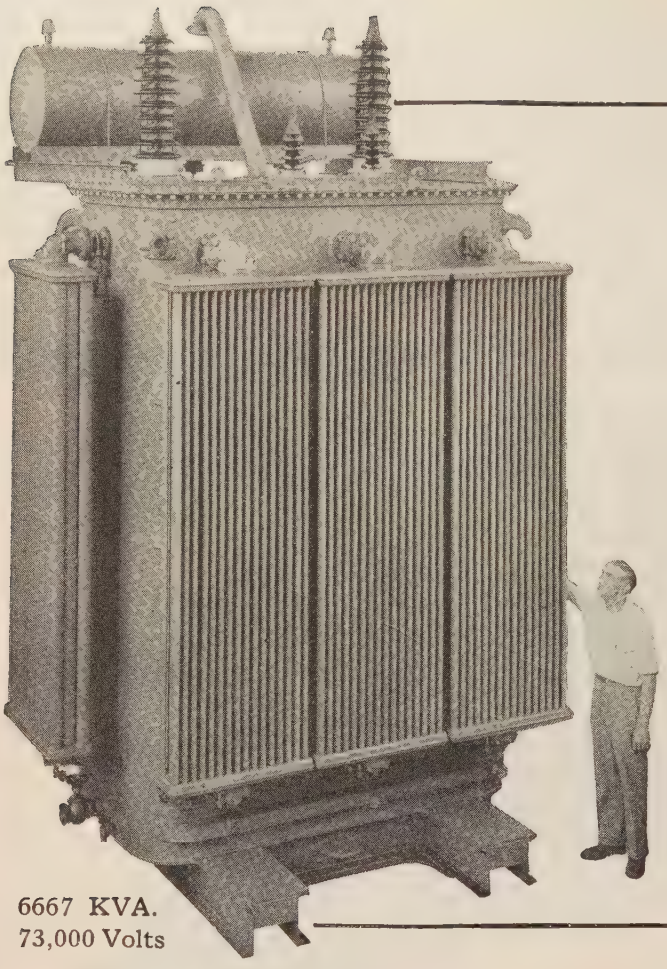
Also manufacturers of Low Voltage Electroplating Generators, variable speed D. C. Motors and Motor-Generators of all kinds.

The Electric Products Co.

CLEVELAND, OHIO

1725 Clarkstone Road

New York Office 126 Liberty St.



6667 KVA.
73,000 Volts

DEPENDABLE

THE design, construction and materials used means that you can depend on a Moloney Transformer for any installation, —generation, transmission, distribution.

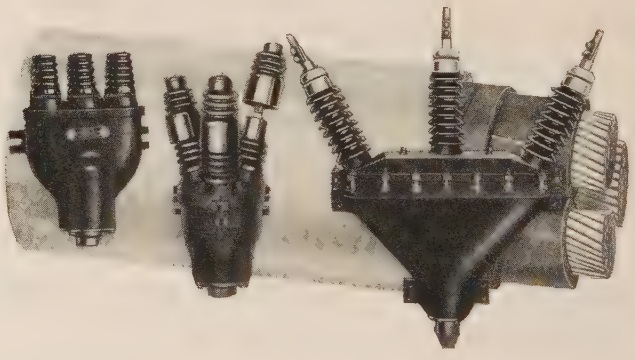
MOLONEY ELECTRIC COMPANY
St. Louis, Mo.

MOLONEY TRANSFORMERS

CABLE TERMINAL DEVICES

G&W ELECTRIC SPECIALTIES

- POTHEADS
- UNDERGROUND CABLE BOXES
- AUTOMATIC TRANSFER SWITCHES
- OIL *and* AIR BREAK DISCONNECTS
- SERIES CUTOUTS
- GROUND PIPE CAPS
- CONDUIT BELLS
- CABLE HEADS
- CABLE COUPLINGS
- CABLE SUPPORTS
- INSULATING SLEEVES
- INSULATING COMPOUND



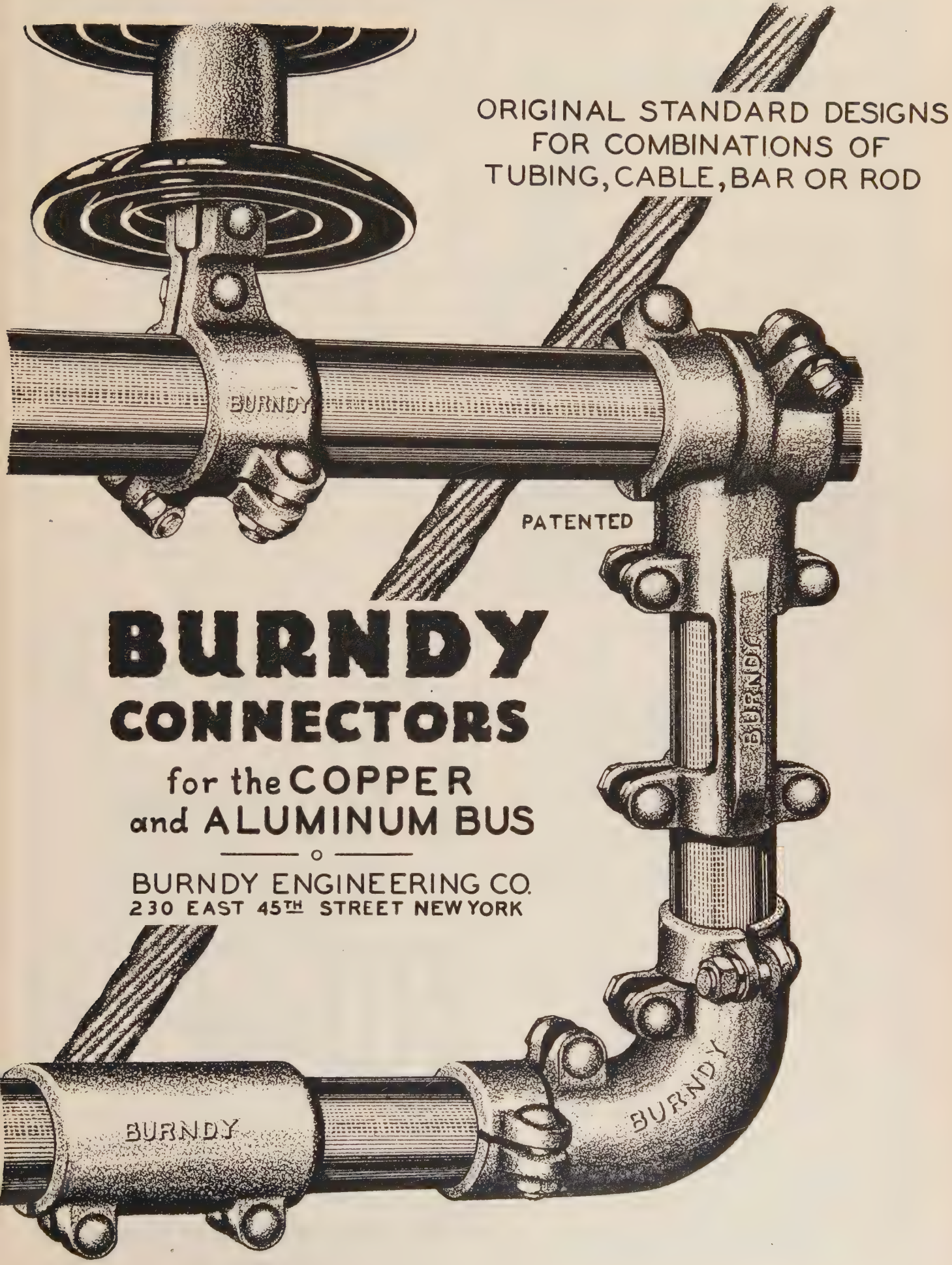
By concentrating on cable terminal devices for twenty-five years The G & W Electric Specialty Co. has developed many practical designs which have been widely accepted. Why not benefit from this experience and concentration?

LET US KNOW WHAT YOU WANT

CABLE TERMINAL DEVICES

G&W Electric Specialty Co.

7780 DANTE AVENUE, CHICAGO, ILLINOIS. REPRESENTATIVES IN PRINCIPAL CITIES


ORIGINAL STANDARD DESIGNS
FOR COMBINATIONS OF
TUBING, CABLE, BAR OR ROD
BURNDY
PATENTED
BURNDY
CONNECTORS
for the COPPER
and ALUMINUM BUS
BURNDY ENGINEERING CO.
230 EAST 45TH STREET NEW YORK
BURNDY
BURNDY

"ANOROC"

Prevents Corona ---

Eliminates Ozone

on rubber insulated high tension cables



Voltage stress in air, either within or about a rubber insulated high voltage cable is likely to cause corona, the formation of ozone and damage to the insulation similar to that shown in the illustration.

Instead of trying to overcome the ozone hazard with metallic shields, protective coverings or so called ozone proof or ozone resisting insulation, we approached the problem from another angle and designed a new type of rubber insulation called "ANOROC" (corona from another angle) which prevents the formation of corona and ozone.

"ANOROC" rubber insulation positively prevents the formation of corona and ozone within or about a cable at normal operating voltage. It retains all of the qualities which identify a high grade rubber compound.

Further information and details of tests are contained in a recent Simplex publication entitled "Corona Prevention and Ozone Elimination." May we send a copy to you?

Patent applied for.

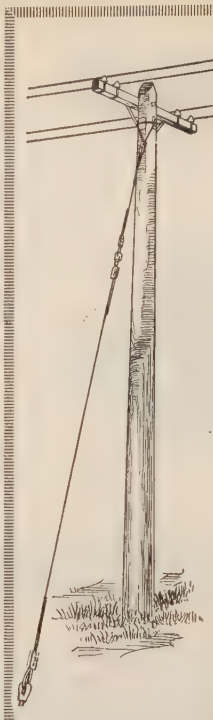
SIMPLEX WIRE & CABLE Co

MANUFACTURERS

201 DEVONSHIRE ST., BOSTON

BRANCH SALES OFFICES

CHICAGO, 564 W. Monroe St. SAN FRANCISCO, 390 Fourth St.
NEW YORK, 1328 B'way CLEVELAND, 2019 Union Trust Bldg.
PHILADELPHIA, 1227 Fidelity-Philadelphia Trust Building
JACKSONVILLE, 417 Barnett National Bank Building



"COPPERWELD" Guy Wires

Take advantage of the permanent strength of Copperweld strand and have greater safety on overhead construction.

The factors of safety of Copperweld construction are permanent, because Copperweld strand is non-rusting. Original strengths are retained year after year.

Write for Copperweld Engineering Data

Copperweld Steel Company

General Offices and Mills

Glassport, Penna.

KEARNEY



FUSE-SWITCHES

OTHER KEARNEY PRODUCTS

Screw Anchors—4 in 1 Expansion Anchors—Guy Wire Clips—Double Duty Cutouts—Solderless Wire Connectors—Single Insulator Fuse-Switches—Fuse Choke Coil Combinations—Sleeve Twisters—Live Line Tools and Accessories.

Complete Catalog Sent On Request

JAMES R. KEARNEY CORPORATION

4220 CLAYTON AVE. ST. LOUIS, MO.

HEMINGRAY GLASS INSULATORS

The transparency of Hemingray Glass Insulators makes line inspection very simple. The lineman can tell at a glance whether the insulator is intact or not. Hemingray insulators are mechanically and dielectrically dependable, non-porous and uniform in structure. They defy moisture and age.

Send for Bulletin No. 1.

HEMINGRAY GLASS COMPANY

Muncie, Indiana

Roebling

Electrical Wires & Cables

High in
Conductivity
and Reliability



John A. Roebling's
Sons Company
Trenton, New Jersey

MEMCO

Insulator Clamps
Copper Fittings
Splicing Sleeves
Disconnects
Choke Coils
Fuse Mountings
Substation Combinations
Air Break Switches
Bus Supports

Memco builds this equipment in all standard and special sizes—ask for bulletins of interest to you.

Memco Engineering & Manufacturing Company, Inc.
381 Hamilton Street, Long Island City, N. Y.

Cable-Pulling Compound

Saves the cable and cuts the pulling time. A modern cable lubricant.



When Minerallac Cable Pulling Compound is used — the lead sheath is not damaged.

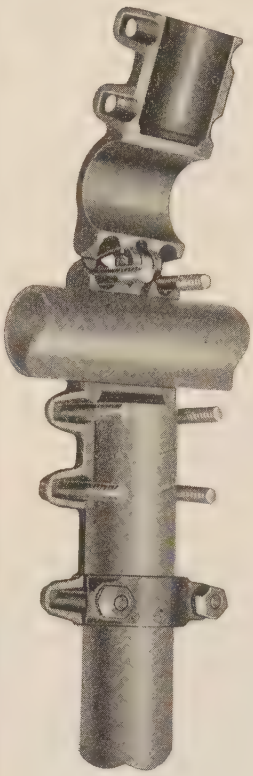
Send for literature

MINERALLAC ELECTRIC COMPANY
25 North Peoria St., Chicago
Please send me folder on Minerallac Pulling Compound.

Name.....
Position.....
Company.....
Address..... Street
City and State.....

BURKE CONNECTORS

reduce installation costs

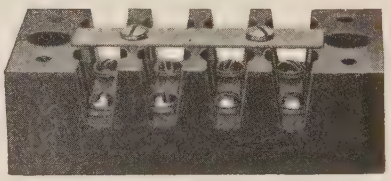


Simplicity of design is a feature of the BURKE Connector. The Connector and tap may be assembled by the workman while on the ground. This assembly is elevated as a unit to the run. The workman, in the air, simply opens the hinge clamp and places it over the run. He has both hands free to insert and tighten the bolts—a wrench is all you need.

See Bulletin C.T.4

CLAMP AND HINGE TYPES

BURKE Connectors are properly designed to meet the mechanical requirements for strength and to provide ample current carrying capacity. The castings are made of all copper resulting in high conductivity.



CONTROLEAD TERMINAL BLOCKS

BURKE Terminal Blocks are moulded of genuine "BAKELITE". They are built in three styles and five sizes. With this selection of sizes and by the use of the interchangeable accessory parts BURKE Controlead Terminal Blocks may be adapted to almost any control wiring circuit.

A new issue of Bulletin H2 illustrates and describes the complete line.

Write for your copy

Alternating and Direct Current Motors and Generators, Motor Generator Sets, Arc Welding Equipment.

BURKE
ELECTRIC COMPANY
main office and works: ERIE, PA.

Universal Motors Copper Connectors, Moulded Burkelect Insulators, Controlead Terminal Blocks.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES

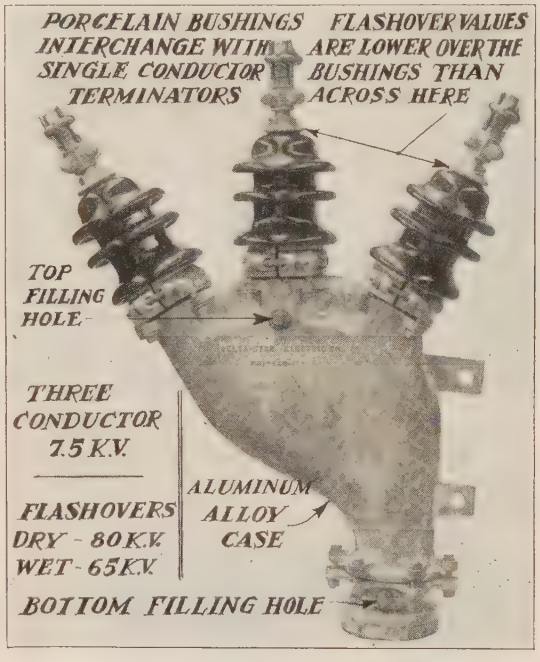
WE DESIGN and manufacture a variety of electrical instruments and accessories for making measurements in the communication-frequency spectrum (0 to several million cycles per second). Our catalog lists the complete line of stock items and indicates the kind of special work we are prepared to undertake. Write for Catalog F-J.

GENERAL RADIO COMPANY

Manufacturers of Electrical Measuring Apparatus for Laboratory and Industrial Use

CAMBRIDGE A, MASSACHUSETTS

Frequency Standards
Tube and Tuning-Fork Oscillators
Bridges
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Calibrated Inductors
Variable Air Condensers
Attenuation Networks
Voltage Dividers
String Oscillograph
Thermionic and Oxide-Rectifier Voltmeters
Rheostats, Transformers, Relays, etc.



TERMINATORS

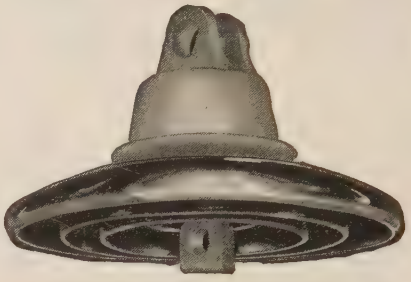
Bull. 65-B

A roomy interior. Cables fanned without excessive bending. Phasing out facilitated by oversize cable entrance and large lower sections. In many cases it will replace the elbow type.

Delta-Star Electric Co

2400 BLOCK, FULTON ST., CHICAGO

INSULATORS

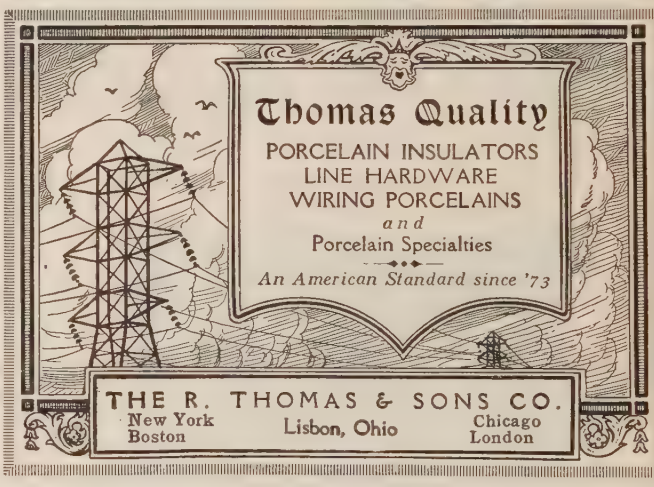


CANADIAN PORCELAIN CO., Ltd.

Hamilton—Ontario—Canada

Quebec District Office 612 Transportation Bldg. Montreal, Qu.

London Office 343 Abbey House, 4 Victoria Street London, S. W. 1.



ASK US FOR A LIST OF CUSTOMERS

From Your or Any Other State in the Union

Every One a Reference for Our Service and Quality of Our TRANSFORMERS



We are exclusively TRANSFORMER specialists. We handle nothing else.
We sell, buy, repair and maintain TRANSFORMERS ONLY.

The ELECTRIC SERVICE CO. Inc.
America's Used Transformer Clearing House
212 Walnut Street Cincinnati, Ohio



We buy modern type transformers—any size—any quantity.
Wanted especially—high voltage large capacity transformers in carload shipments.

Chandeysson

Generators
25 to 25,000 Amperes

Direct Connected to

General Electric Motors



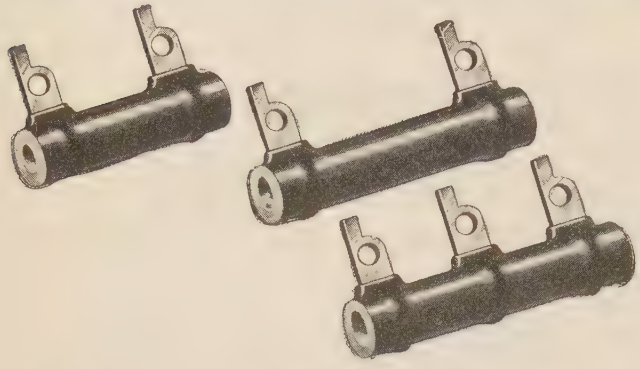
20,000 AMPERE 12 VOLT UNIT

WEIGHT 85,600 POUNDS

FABRICATED STEEL SUB-BASE

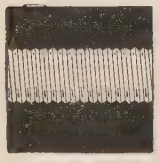
CHANDEYSSON ELECTRIC CO., St. Louis, U. S. A.

VITROHM (WL) RESISTORS



Quantity — One

IF your resistor requirements are modest in quantity, and if you have been using home-made or other resistors because the question of cost deterred you from using the best, we would appreciate quoting on your requirements.



The pitchrod determines the accuracy of winding wire on tubes

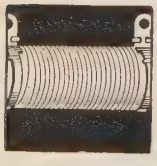
A million VITROHM (WL) RESISTORS are made one at a time. Each individual resistor is carefully wound, thoroughly protected with enamel, and accurately tested. Each resistor is truly "hand-made" with all advantages of large production. May we receive your next order of "Quantity — One"?



The tension of the wire must be correct



Lack of accuracy in pitch or tension will cause shorted turns or



If a perfect winding like this is to result



"Swimming" of wire after one coat of enamel is fused on



Control of these factors is perfect. Two wire sizes are often wound on one tube.

WARD LEONARD ELECTRIC CO.
Mount Vernon, New York
resistor specialists for more than 39 years



LAVA
Threaded Cores

Offer the advantages of a perfect DIELECTRIC and HEAT resistant insulator MADE within the CLOSEST of tolerances.

Inquiries Solicited

AMERICAN LAVA CORPORATION
27-67 Williamson St.
CHATTANOOGA, TENNESSEE

Manufacturers of Electric & Heat Resistant Insulators

ELECTRITE

A high grade fibre board for electrical insulation.

A material of quality possessing high tensile and dielectric strength.

Tested and approved by the Underwriters' Laboratories.

Pulp Products Department

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Oster Electric Hair Clipper, made by John Oster Mfg. Co., Racine, Wis. Whisk Electric Safety Razor, made by Whisk Razor Corp., Buffalo, N.Y. Both have Bakelite Molded handles.

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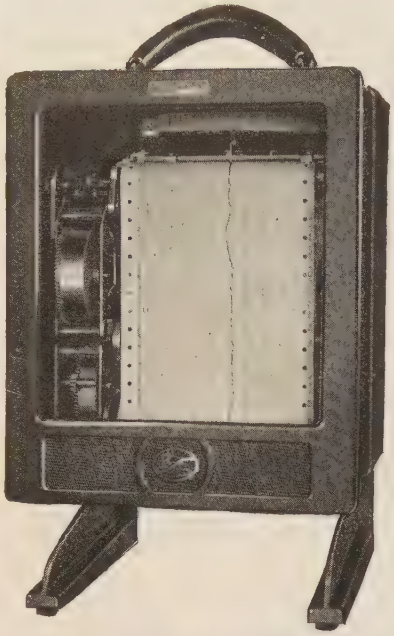
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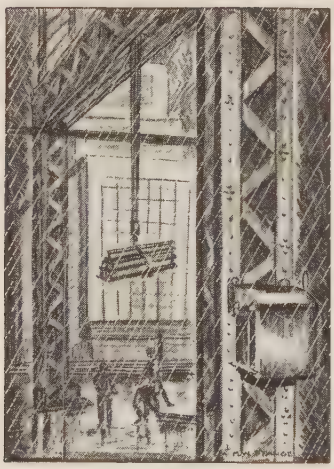
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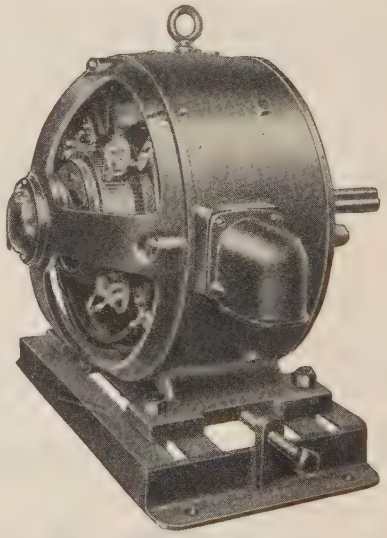
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In case of fire—all machinery controlled by over 40 EC&M Starters must stop—one switch does it

The above illustration shows the installation of more than 40 EC&M Oil-immersed Automatic Motor Starters in a large varnish manufacturing plant recently completed in an eastern city. Each starter controls some piece of equipment located throughout the plant.

In case of fire, all of the machinery must be stopped at once. This is accomplished by merely throwing a main switch which disconnects all equipment.

Likewise important, however, as this interesting feature planned by this customer's engineers, is the dependability of EC&M Oil-immersed Motor Starters. The oil-immersed feature not only provides a flameproof installation, but also insures the equipment is always in operating condition . . . all parts are well lubricated and protected against dust and corrosion.

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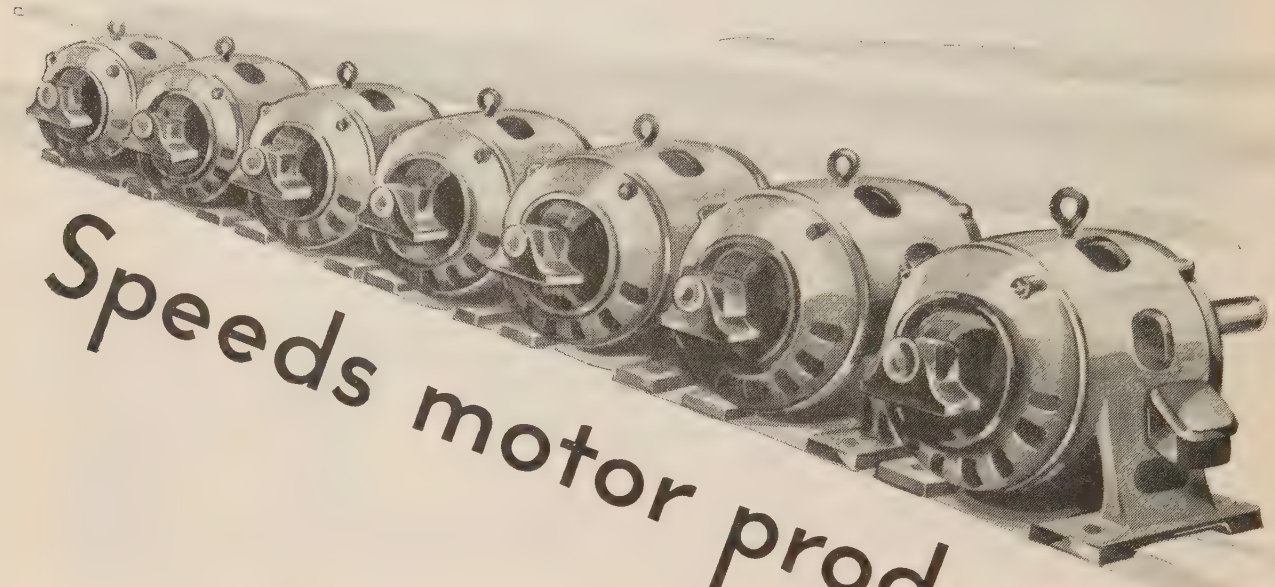
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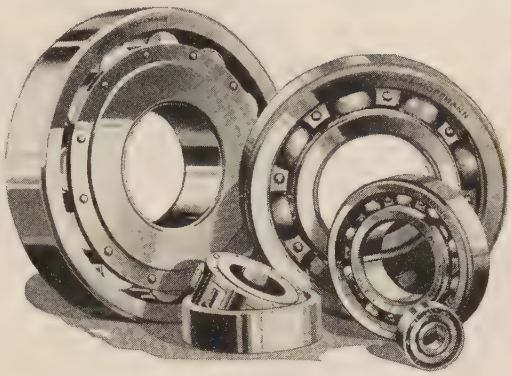
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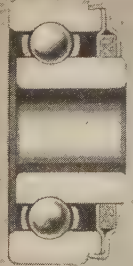
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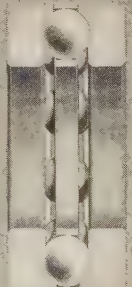

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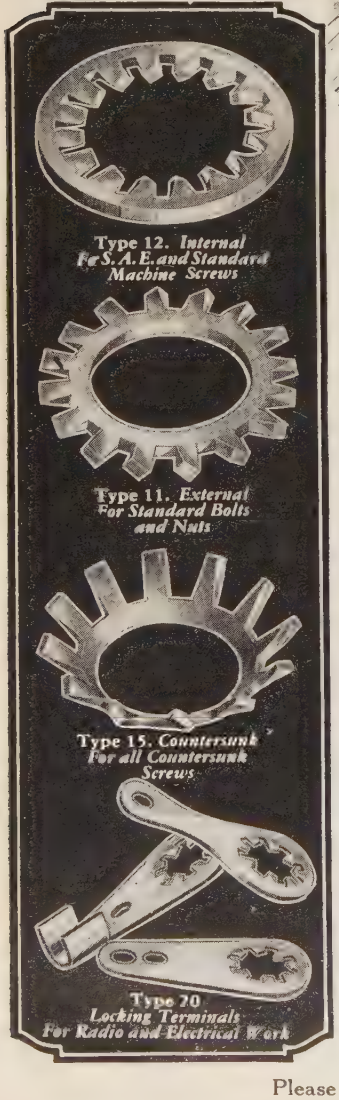

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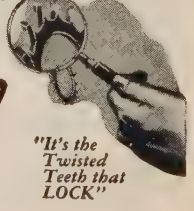
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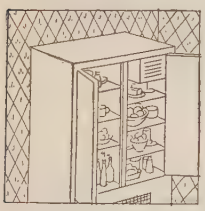
Presents facts and figures on fastening methods which have proved particularly advantageous.

TO help you attain greater fastening economy this interesting and informative booklet has just been published. It was prepared with the cooperation of fourteen of the most prominent manufacturers in their respective fields, who permitted a nationally known firm of engineers to enter their plants and make studies of fastening methods which have proved particularly advantageous.

Certified facts and figures from those studies make up the booklet. Every production executive who is interested in attaining faster, easier, more economical assembly of a product made wholly or partly of metal should read with great interest such accounts as:

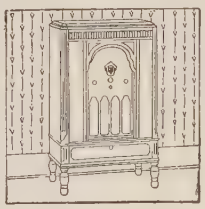


Servel saves $64,120 a year . . .



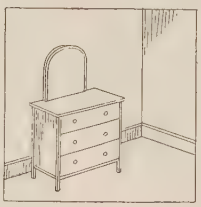
by assembling the exterior metal sheathing of their refrigerator cabinets with Hardened Self-tapping Sheet Metal Screws. This story of fastening economy is told by one of Servel's engineers, who describes the former methods of making the assembly, as well as the present method which eliminates a skeleton frame-work of wood with a saving of $1.00 per cabinet.

44 tapping operations eliminated on Philco Radio



by fastening parts to the chassis with Hardened Self-tapping Sheet Metal Screws. The details of this achievement are particularly interesting since few products require more assembly work than a radio receiver. This report also explains the severe tests by which Philco determines the security of a fastening.

50% saving made by Doehler . . .



through the use of Self-tapping Screws on both vending machine and metal furniture assemblies. In this fastening study, the Chief Engineer of Doehler Die Casting Co. discusses alternative methods of fastening to die castings and of assembling sheet metal.

Enormous savings effected in auto production . . .



where fastening devices are selected with utmost care. That such effort pays, is proved by an account of the way a great builder of auto bodies saved $150,000 in a year by using Self-tapping Sheet Metal Screws for making fastenings to sheet metal.

Every study is worth reading!

All of the fastening studies in this book are interesting. Other contributors include: Zenith-Detroit, Gilbert and Barker, Stout, Edison and Simmons.

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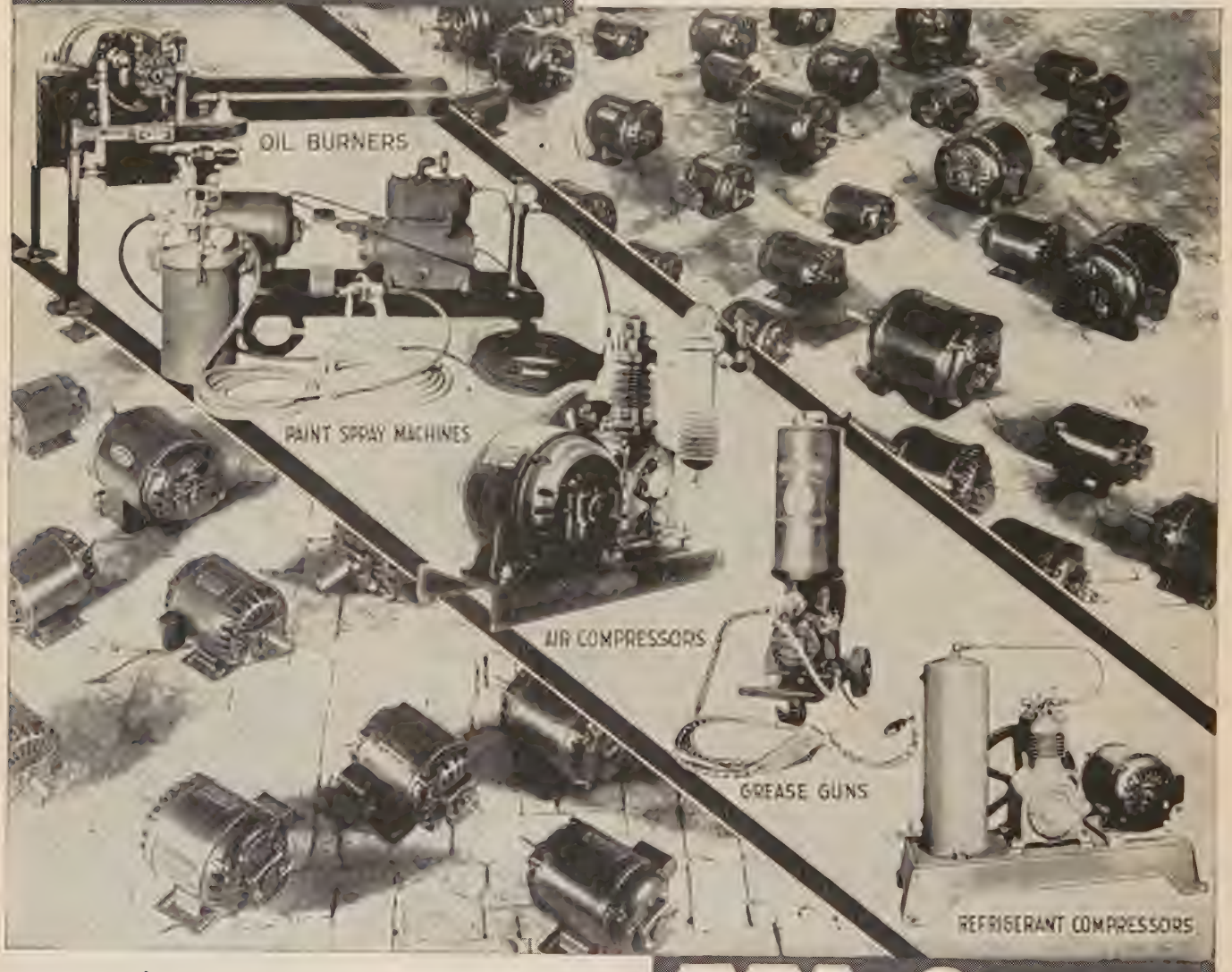
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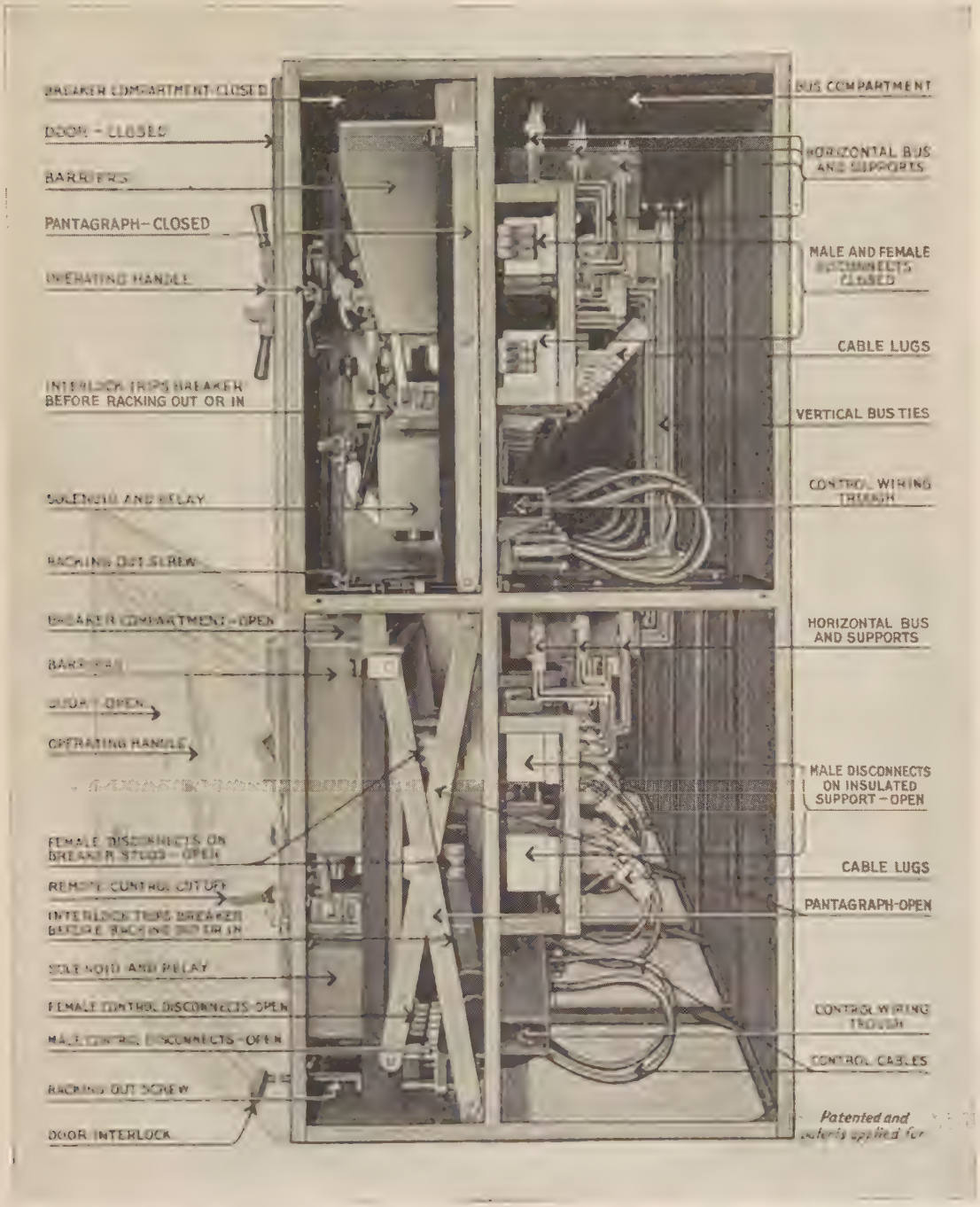
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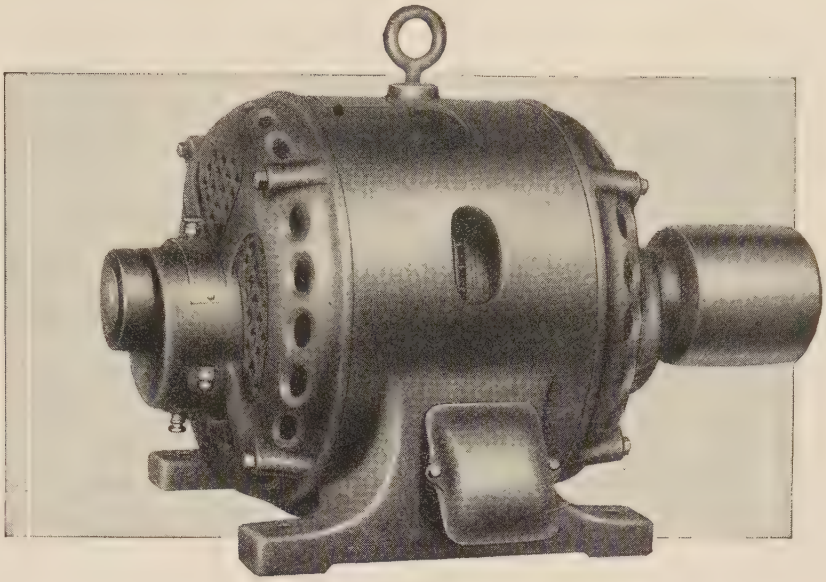
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DESIGN AND CONSTRUCTION
EXAMINATIONS REPORTS
APPRAISALS
INDUSTRIAL AND PUBLIC SERVICE PROPERTIES
New York Boston Chicago

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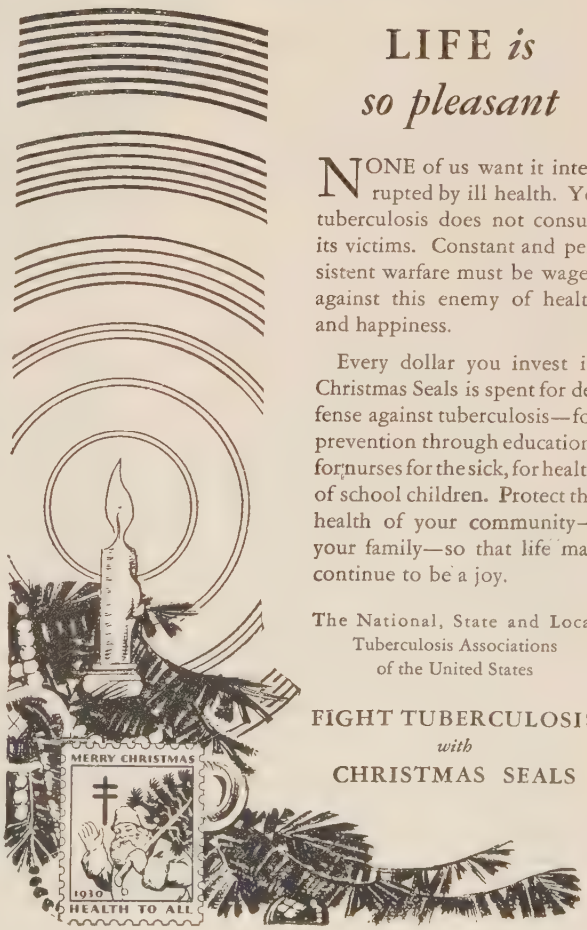
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LIFE *is so pleasant*

NONE of us want it interrupted by ill health. Yet tuberculosis does not consult its victims. Constant and persistent warfare must be waged against this enemy of health and happiness.

Every dollar you invest in Christmas Seals is spent for defense against tuberculosis—for prevention through education, for nurses for the sick, for health of school children. Protect the health of your community—your family—so that life may continue to be a joy.

The National, State and Local Tuberculosis Associations of the United States

FIGHT TUBERCULOSIS *with* CHRISTMAS SEALS

Classified Advertiser's Index for Buyers

Manufacturers and agents for machinery and supplies used in the electrical and allied industries.

Note: For reference to the advertisements see the Alphabetical List of Advertisers on page 54.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Western Electric Co., All Principal Cities

AMMETER COMPENSATING COILS
Minerallac Electric Co., Chicago

AMMETER, VOLTMETERS
(See INSTRUMENTS, ELECTRICAL)

ANCHORS, GUY
Copperweld Steel Co., Glassport, Pa.
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis

BATTERY CHARGING APPARATUS
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BEARINGS, BALL
Norma-Hoffman Bearings Corp., Stamford, Conn.

BOXES, FUSE
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BOXES, JUNCTION
Burke Electric Co., Erie, Pa.
G & W Elec. Specialty Co., Chicago
General Cable Corporation, New York
Metropolitan Device Corp., Brooklyn, N. Y.

BRUSHES, COMMUTATOR
Carbon
Morganite Brush Co., Inc., L. I. City, N. Y.
National Carbon Co., Inc., Cleveland
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Copper Graphite
Morganite Brush Co., Inc., L. I. City, N. Y.
National Carbon Co., Inc., Cleveland
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUS BARS, ALUMINUM
Aluminum Co. of America, Pittsburgh

BUS BAR FITTINGS
Burke Electric Co., Erie, Pa.
Burndy Engineering Co., Inc., New York
Champion Switch Co., Kenova, West Va.
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUSHINGS, PORCELAIN
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CABLE ACCESSORIES
Burke Electric Co., Erie, Pa.
Champion Switch Co., Kenova, West Va.
Delta-Star Electric Co., Chicago
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Western Electric Co., All Principal Cities

CABLE RACKS
Metropolitan Device Corp., Brooklyn, N. Y.

CABLES
SEE WIRES AND CABLES

CABLEWAYS
American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.

CASTINGS, ALUMINUM
Aluminum Co. of America, Pittsburgh

CIRCUIT BREAKERS
Air—Enclosed
Condit Elec. Mfg. Corp., Boston
I-T-E Circuit Breaker Co., The, Philadelphia
Roller-Smith Co., New York
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Western Electric Co., All Principal Cities
Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CLAMPS, GUY & CABLE
Burke Electric Co., Erie, Pa.
Burndy Engineering Co., Inc., New York
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis

CLAMPS, INSULATOR
Champion Switch Co., Kenova, West Va.
Memco Engg. & Mfg. Co., L. I. City, N. Y.

COILS, CHOKE
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COILS, MAGNET
Belden Mfg. Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COMMUTATOR SEGMENTS AND RINGS
Mica Insulator Co., New York

CONDENSATION PRODUCTS
Bakelite Corporation, New York

CONDENSERS, RADIO
General Radio Co., Cambridge, Mass.
Sangamo Electric Co., Springfield, Ill.

CONDENSERS, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONDUIT, UNDERGROUND FIBRE
Western Electric Co., All Principal Cities

CONNECTORS, SOLDERLESS
Burke Electric Co., Erie, Pa.
Dossert & Co., New York
Kearney Corp., Jas. R., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONNECTORS AND TERMINALS
Belden Mfg. Co., Chicago
Burke Electric Co., Erie, Pa.
Burndy Engineering Co., Inc., New York
Champion Switch Co., Kenova, West Va.
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONTACTS, TUNGSTEN
General Electric Co., Schenectady

CONTROL SYSTEMS
Ward Leonard Electric Co., Mt. Vernon, N.Y.

CONTROLLERS
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Rowan Controller Co., Baltimore, Md.
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONVERTERS—SYNCHRONOUS
Allis-Chalmers Mfg. Co., Milwaukee
Electric Specialty Co., Stamford, Conn.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COPPER CLAD WIRE
Belden Mfg. Co., Chicago
Western Electric Co., All Principal Cities

COPPERWELD WIRE
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York

CUT-OUTS
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., S. Boston
General Electric Co., Schenectady
G & W Electric Specialty Co., Chicago
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

DIMMERS, THEATRE
Ward Leonard Electric Co., Mt. Vernon, N.Y.

DIVERTER POLE GENERATORS
Electric Products Co., Cleveland, O.

DYNAMOS
(See GENERATORS AND MOTORS)

DYNAMOTORS
Burke Electric Co., Erie, Pa.
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.

ELECTRIFICATION SUPPLIES, STEAM ROAD
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, Ohio
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

ENGINEERS, CONSULTING AND CONTRACTING
(See PROFESSIONAL ENGINEERING DIRECTORY)

ENGINES
Gas & Gasoline
Allis-Chalmers Mfg. Co., Milwaukee
Oil
Allis-Chalmers Mfg. Co., Milwaukee
Steam
Allis-Chalmers Mfg. Co., Milwaukee

EXPERIMENTAL WORK
Manufacturers' and Inventors' Electric Co., New York

FANS, MOTORS
Century Electric Co., St. Louis
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FLOW METERS
General Electric Co., Schenectady

FURNACES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FUSES
Enclosed Refillable
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Enclosed Non-Refillable
General Electric Co., Schenectady
Open Link
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
High-Tension
Metropolitan Device Corp., Brooklyn, N. Y.

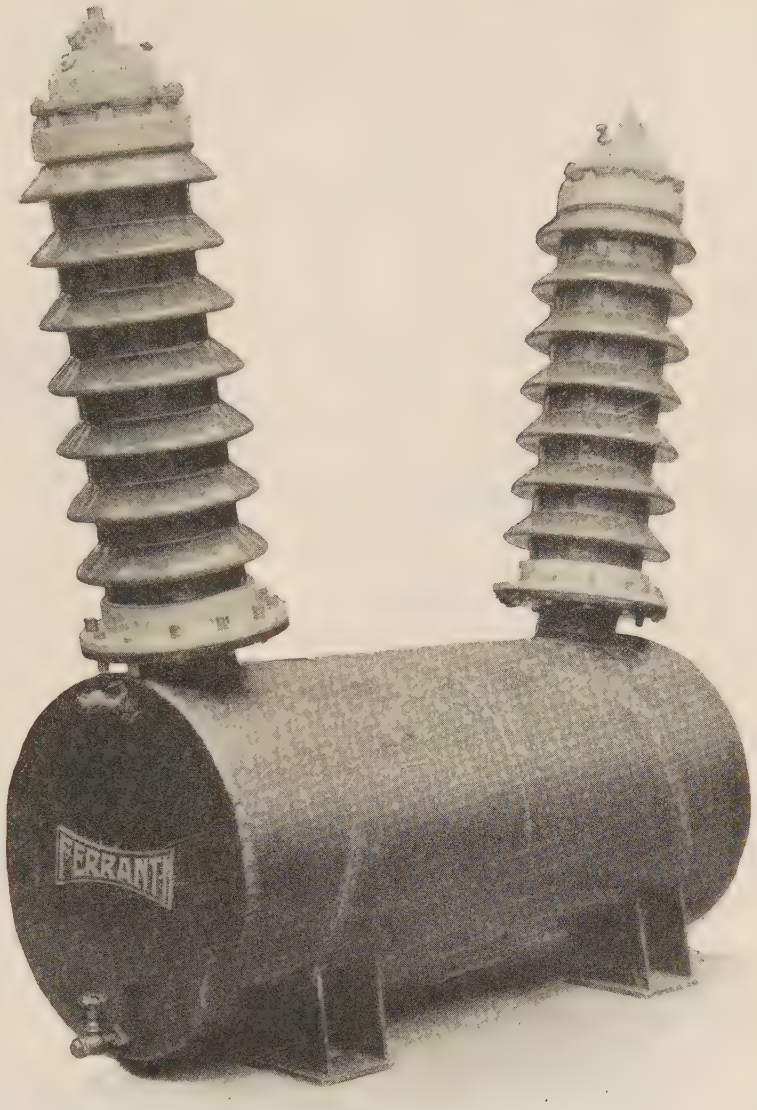
FUSE MOUNTINGS
Memco Engg. & Mfg. Co., L. I. City, N. Y.

FUSE PULLERS
Kearney Corp., Jas. R., St. Louis



Morganite Brushes
Morganite Brush Co., Inc.
3302-3320 Anable Ave., Long Island City, N. Y.

Ferranti Transformers



60,000 Volt
50 Ampere
Single Phase
Ferranti Surge
Absorber Unit

Ferranti Surge Absorbers protect high tension equipment against damage from lightning and line surges

High Tension Transformers
Distribution Transformers
High Voltage A.C. and D.C. Test Sets
D.C. Watthour Meters

A.C. Watthour Meters
High Tension Line Protection
Electric Hot Water Boilers
Non-Magnetic Cast Iron

Ferranti, Ltd.
Hollinwood
England

Ferranti, Inc.
130 West 42nd Street
New York, N. Y.

Ferranti Electric, Ltd.
26 Noble Street
Toronto, Canada

Classified Advertiser's Index for Buyers—*Continued*

GEARS, FIBRE
General Electric Co., Schenectady

GENERATORS AND MOTORS
Allis-Chalmers Mfg. Co., Milwaukee
Burke Electric Co., Erie, Pa.
Century Electric Co., St. Louis
Chandeysson Electric Co., St. Louis
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.
Electro-Dynamic Co., Bayonne, N. J.
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

GENERATING STATION EQUIPMENT
Allis-Chalmers Mfg. Co., Milwaukee
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

GROUND RODS
Copperweld Steel Co., Glassport, Pa.

HARDWARE, POLE LINE AND INSULATOR
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

HEADLIGHTS
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

HEATERS, INDUSTRIAL
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INDICATORS, REMOTE, WATER LEVEL
Bristol Co., The, Waterbury, Conn.

INDICATORS, SPEED
Bristol Co., The, Waterbury, Conn.
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.

INSTRUMENTS, ELECTRICAL

Graphic
Bristol Co., The, Waterbury, Conn.
Cambridge Instrument Co., New York
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Indicating
Bristol Co., The, Waterbury, Conn.
Cambridge Instrument Co., New York
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Sangamo Electric Co., Springfield, Ill.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.

Integrating
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Sangamo Electric Co., Springfield, Ill.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Radio
Cambridge Instrument Co., New York
General Radio Co., Cambridge, Mass.
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.

Repairing and Testing
Cambridge Instrument Co., New York
Electrical Testing Laboratories, New York
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.

Scientific Laboratory, Testing
Cambridge Instrument Co., New York
General Electric Co., Schenectady
Jewell Elec. Instrument Co., Chicago
Metropolitan Device Corp., Brooklyn, N. Y.
Roller-Smith Co., New York
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.

INSULATING MATERIALS

Board
General Electric Co., Bridgeport, Conn.
West Va. Pulp & Paper Co., New York

Cloth
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INSULATING MATERIALS—*Continued*

Composition
American Lava Corp., Chattanooga
Bakelite Corporation, New York
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Compounds
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Standard Underground Cable Co., Perth Amboy, N. J.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Fibre
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
West Va. Pulp & Paper Co., New York

Lava
American Lava Corp., Chattanooga, Tenn.

Mica
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Paper
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Silk
General Electric Co., Bridgeport, Conn.

Tape
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Okonite Co., The, Passaic, N. J.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Varnishes
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INSULATORS, HIGH TENSION

Composition
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady

Glass
Hemingray Glass Co., Muncie, Ind.

Porcelain
Canadian Porcelain Co., Ltd., Hamilton, Ont.
Champion Switch Co., Kenova, West Va.
General Electric Co., Schenectady
Lapp Insulator Co., Inc., LeRoy, N. Y.
Locke Insulator Corp., Baltimore
Ohio Brass Co., Mansfield, O.
Thomas & Sons Co., R., Lisbon, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Post Type
Delta-Star Electric Co., Chicago
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INSULATORS, TELEPHONE & TELEGRAPH
Hemingray Glass Co., Muncie, Ind.
Ohio Brass Co., Mansfield, O.

INSULATOR PINS
Ohio Brass Co., Mansfield, O.
Thomas & Sons Co., R., Lisbon, O.

LAMP GUARDS
Matthews Corp., W. N., St. Louis

LAVA
American Lava Corp., Chattanooga

LIGHTNING ARRESTERS
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

LOCOMOTIVES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

MAGNETIC SEPARATORS
Electric Controller & Mfg. Co., Cleveland

METERS, ELECTRICAL
(See INSTRUMENTS ELECTRICAL)

METER SEALS
Metropolitan Device Corp., Brooklyn, N. Y.

MICA PRODUCTS
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

MOLDED INSULATION
Bakelite Corporation, New York
Belden Mfg. Co., Chicago
Burke Electric Co., Erie, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

MOTORS
(See GENERATORS AND MOTORS)

OHMMETERS
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Weston Elec. Instr. Corp., Newark, N. J.

OIL SEPARATORS & PURIFIERS
Sharples Specialty Co., The, Philadelphia
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

PANEL BOARDS
(See SWITCHBOARDS)

PATENT ATTORNEYS
(See PROFESSIONAL ENGINEERING DIRECTORY)

PLATING GENERATORS
Burke Electric Co., Erie, Pa.
Chandeysson Elec. Co., St. Louis
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.

PLUGS
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

POLE LINE HARDWARE
Ohio Brass Co., Mansfield, O.

POTHEADS
G & W Electric Specialty Co., Chicago
General Cable Corporation, New York
Ohio Brass Co., Mansfield, O.

PUBLIC ADDRESS SYSTEMS
Western Electric Co., All Principal Cities

PULLERS, SLACK
Matthews Corp., W. N., St. Louis

PUMPS
Allis-Chalmers Mfg. Co., Milwaukee

RADIO LABORATORY APPARATUS
General Radio Co., Cambridge, Mass.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

RAILWAY SUPPLIES, ELECTRIC
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

REACTORS
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.

RECTIFIERS
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

REELS, PAYOUT AND TAKEUP
Matthews Corp., W. N., St. Louis

REGULATORS, VOLTAGE
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

RELAYS
Condit Elec. Mfg. Corp., Boston
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

RESISTORS, VITREOUS
Electrad, Inc., New York
International Resistance Co., Philadelphia
Ward Leonard Electric Co., Mt. Vernon, N.Y.

RESISTOR UNITS
Electrad, Inc., New York
General Electric Co., Schenectady
International Resistance Co., Philadelphia
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

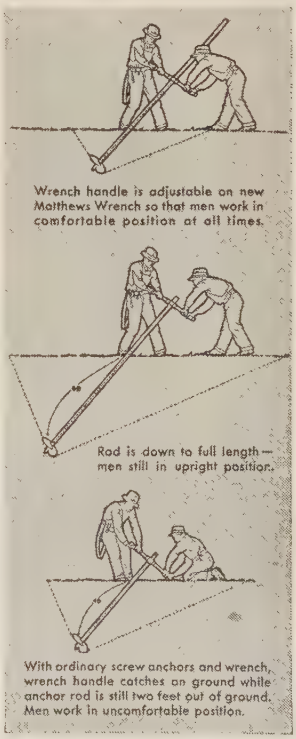
RHEOSTATS
General Electric Co., Schenectady
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

ROPE, WIRE
American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.



Matthews Scrulix Anchors
go all the way down—quickly

Full rod length installations mean greater holding power. Matthews Scrulix Anchors guarantee 50% greater, but many tests show as much as 100%. By using the 6810 Matthews Wrench, the malleable Matthews Scrulix Anchors are easy to screw all the way down—providing an installation of about two feet deeper because with the ordinary screw anchors it is exceedingly difficult to get a six-foot anchor down more than four feet. Hard pan, baked clay and disintegrated rock installations are made easy by first boring a small pilot hole with the 381 Matthews Hinglox Earth Auger. For complete information on these Matthews Specialties, send for Bulletin 803.



W. N. MATTHEWS CORPORATION

Engineers and Manufacturers

ST. LOUIS, MO.

Classified Advertiser's Index for Buyers—*Continued*

SCREWS
Drive Hardened Metallic
Parker-Kalon Corp., New York
Self-Tapping Hardened
Parker-Kalon Corp., New York
Sheet Metal, Hardened Self-Tapping:
Parker-Kalon Corp., New York

SEARCHLIGHTS
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SLEEVE TWISTERS
Kearney Corp., Jas. R., St. Louis

SLEEVES, SPLICING
Memco Engg. & Mfg. Co., L. I. City, N. Y.

SOCKETS AND RECEPTACLES
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SOLENOIDS
Belden Mfg. Co., Chicago
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SPRINGS
American Steel & Wire Co., Chicago

STARTERS, MOTORS
Condit Electrical Mfg. Corp., Boston
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

STOKERS, MECHANICAL
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SUB-STATIONS
American Bridge Co., New York
Champion Switch Co., Kenova, West Va.
General Electric Co., Schenectady
Memco Engg. & Mfg. Co., L. I. City, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHBOARDS
Allis-Chalmers Mfg. Co., Milwaukee
Bull Dog Electric Products Co., Detroit
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHES *Automatic Time*
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Sangamo Electric Co., Springfield, Ill.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Disconnecting
Bull Dog Electric Products Co., Detroit
Burke Electric Co., Erie, Pa.
Champion Switch Co., Kenova, West Va.
Condit Electrical Mfg. Corp., Boston
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis
Memo Engg. & Mfg. Co., L. I. City, N. Y.
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Fuse
Bull Dog Electric Products Co., Detroit
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Knife
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Matthews Corp., W. N., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Magnetic
Electric Controller & Mfg. Co., Cleveland
Ward Leonard Electric Co., Mt. Vernon, N.Y.
Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Remote Control
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Roller-Smith Co., New York
Rowan Controller Co., Baltimore, Md.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TELEPHONE CONNECTORS
Kearney Corp., Jas., R., St. Louis

TERMINAL BLOCKS
Burke Electric Co., Erie, Pa.

TESTING LABORATORIES
Electrical Testing Labs., New York

TOWERS, TRANSMISSION
American Bridge Co., New York

TRANSFORMERS
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Electric Service Co., Cincinnati
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis
Sangamo Electric Co., Springfield, Ill.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Factory
American Transformer Co., Newark, N. J.
Kuhlman Electric Co., Bay City, Mich.
Moloney Electric Co., St. Louis, Mo.
Wagner Electric Corp., St. Louis
Furnace
Allis-Chalmers Mfg. Co., Milwaukee
American Transformer Co., Newark, N. J.
Moloney Electric Co., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Metering
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Roller-Smith Co., New York
Sangamo Electric Co., Springfield, Ill.
Weston Elec. Inst. Corp., Newark, N. J.
Radio
American Transformer Co., Newark, N. J.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
Sangamo Electric Co., Springfield, Ill.
Street Lighting
Kuhlman Electric Co., Bay City, Mich.

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Ohio Brass Co., Mansfield, O.
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Gas, Water, Steam
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Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WASHERS, LOCK
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Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
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American Steel & Wire Co., Chicago
Ohio Brass Co., Mansfield, O.

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Aluminum
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Armored Cable
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Asbestos Covered
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Electric Co., Schenectady
Rockbestos Products Corp., New Haven, Conn.
Asbestos, Varnished Cambric
Rockbestos Products Corp., New Haven, Conn.

WIRES AND CABLES—*Continued*
Automotive
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Bare Copper
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Belden Mfg. Co., Chicago
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Copper Clad
Belden Mfg. Co., Chicago
Western Electric Co., All Principal Cities
Copperweld
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Flexible Cord
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Flexible Cord, (Heater) Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Heavy Duty Cord
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Cable Corporation, New York
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Simplex Wire & Cable Co., Boston
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Aluminum Co. of America, Pittsburgh
American Steel & Wire Co., Chicago
General Electric Co., Schenectady.
Roebling's Sons Co., John A., Trenton, N. J.
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Anaconda Wire & Cable Co., New York
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
Okonite Company, The, Passaic, N. J.
Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
Leads, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
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Aluminum Co. of America, Pittsburgh
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Anaconda Wire & Cable Co., New York
Belden Mfg. Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Roebling's Sons Co., John A., Trenton, N. J.
Western Electric Co., All Principal Cities
Magnet, Asbestos Insulated
Rockbestos Products Corp., New Haven, Conn.
Rubber Insulated
American Steel & Wire Co., Chicago
Belden Mfg. Co., Chicago
General Cable Corporation, New York
General Electric Co., Schenectady
Kerite Ins. Wire & Cable Co., New York
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Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Western Electric Co., All Principal Cities
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Rockbestos Products Corp., New Haven, Conn.
Tree Wire
General Cable Corporation, New York
Okonite Company, The, Passaic, N. J.
Roebling's Sons Co., John A., Trenton, N. J.
Simplex Wire & Cable Co., Boston
Trolley
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
Roebling's Sons Co., John A., Trenton, N.J.
Western Electric Co., All Principal Cities
Weatherproof
American Steel & Wire Co., Chicago
Anaconda Wire & Cable Co., New York
Copperweld Steel Co., Glassport, Pa.
General Cable Corporation, New York
General Electric Co., Schenectady
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WOOD RESIN
Hercules Powder Co., Wilmington, Del.



The Laboratories at Corning are gratified indeed by the enthusiastic reception accorded the 70 kv. Pyrex Power Insulator.

In this one-piece insulator, weighing but 36 pounds, engineers have seen the answer to expressed wishes.

The *inherent* characteristics of this insulator preclude porosity and deterioration.

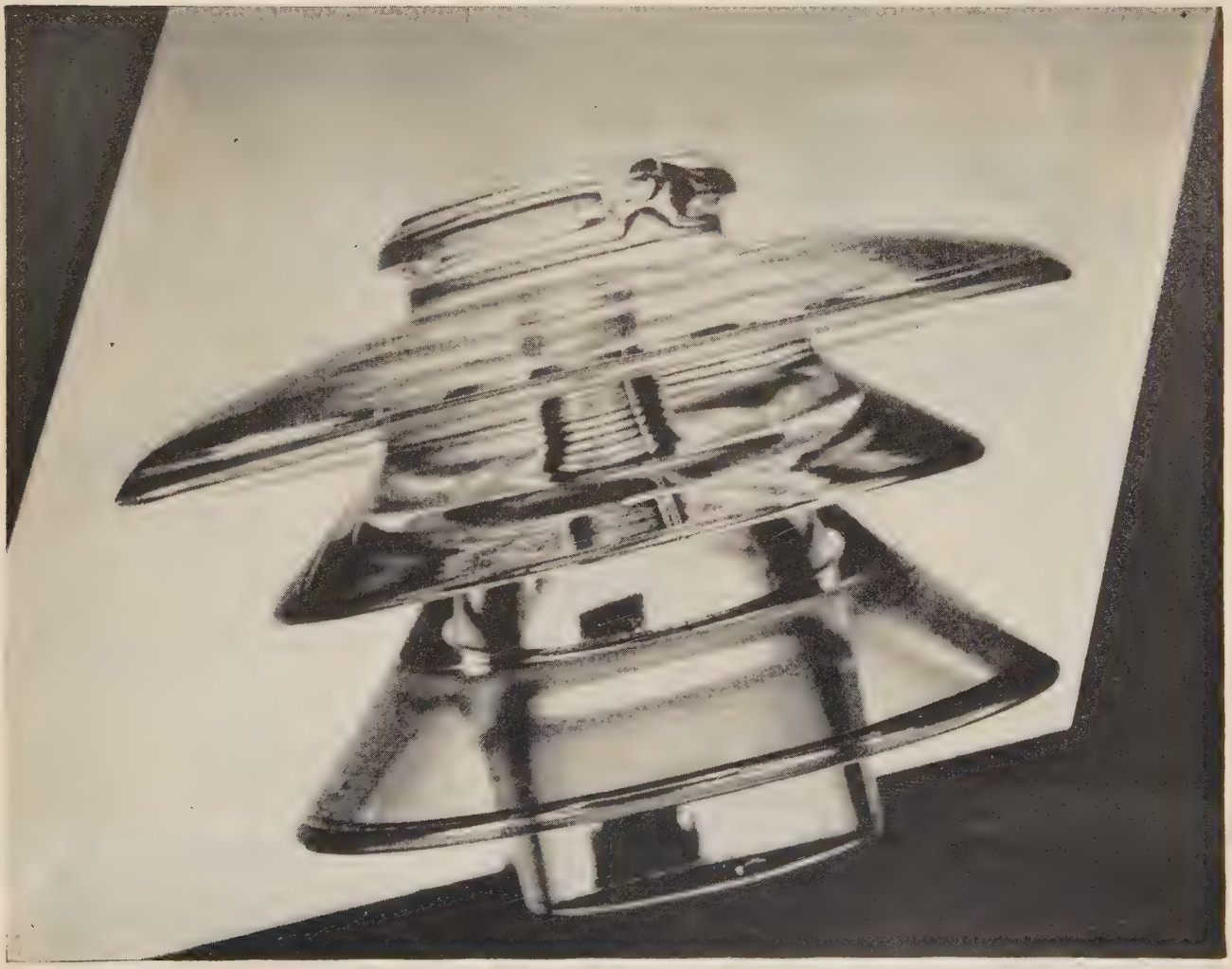
The *inherent* characteristics provide its resistance to power arcs and lightning impulse voltages.

An exclusive feature is the elimination of corona and brush discharges with their attending disturbances.

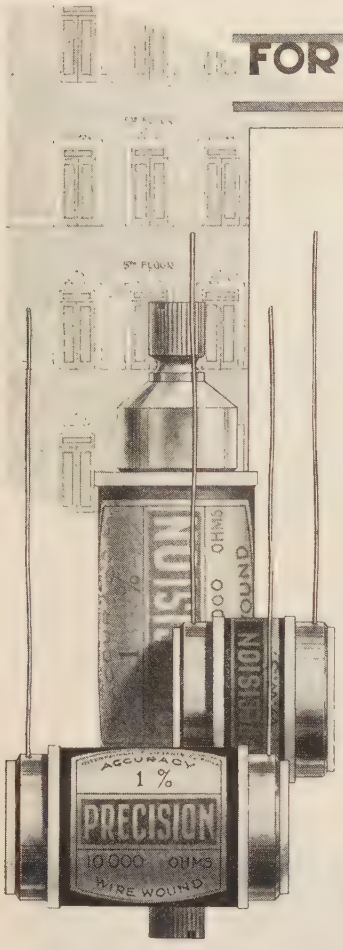
When such unusually large strides are made in any product, they are rarely the result of product refinement. A new principle or new material (the result of scientific research) is usually the influencing factor.

The advantages of the Pyrex* Power Insulator are due to the *material* from which it is made.

*T. M. Reg. U. S. Pat. Off.



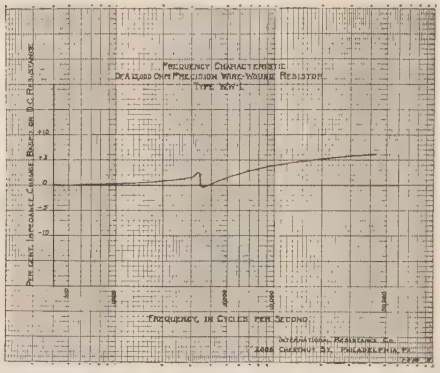
AN ACHIEVEMENT OF CORNING GLASS WORKS, CORNING, N. Y.



FOR SAFETY

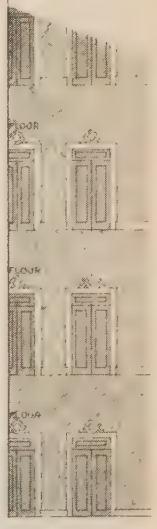
Among the many uses for our Precision Wire Wound Resistors is in connection with safety devices on elevator doors.

One of the salient qualities of our new Precision Wire Wound Resistors is illustrated in the graph below. This shows the change in impedance with frequency. The maximum change under 50,000 cycles is so low that it can be used in the most exacting work. It will be noticed that the break in the curve is almost imperceptible. The temperature co-efficient of resistance is 0.0002 per °C. These resistors have a safe power rating of 1 watt.



Among the other features are our noiseless contacts in which special alloy ends are actually molded into the units, our ceramic form, our special wire, our exclusive winding process and double testing.

From 1 ohm to 200 megohms, we can meet your resistor requirements. Write us stating your resistor problems and allow our engineering department to assist if possible.



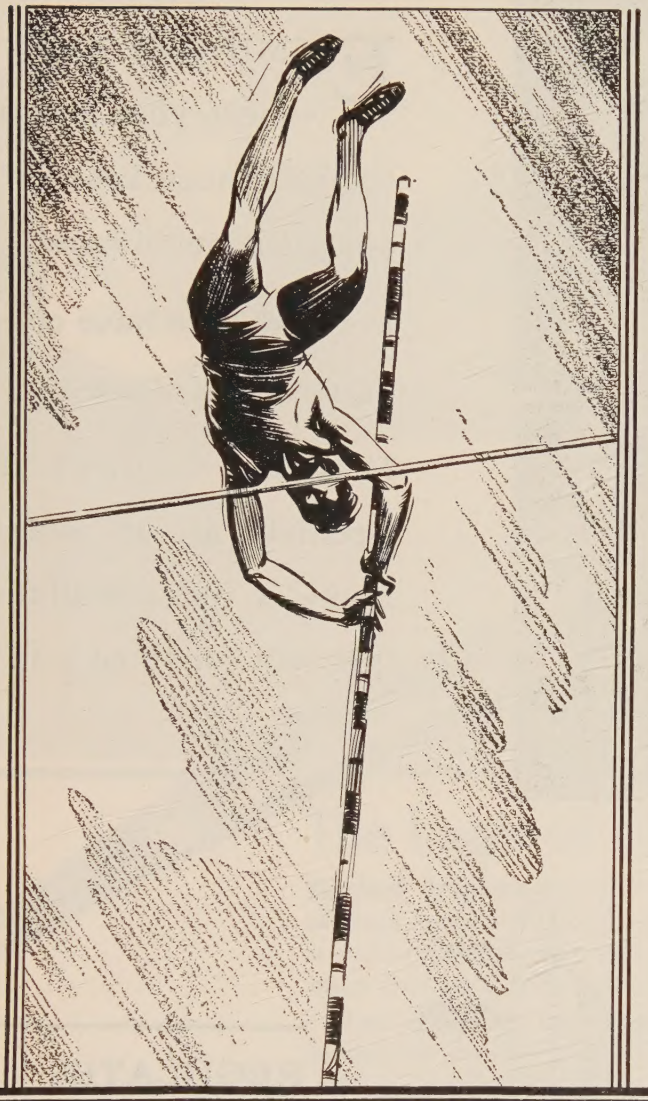
INTERNATIONAL RESISTANCE COMPANY
2006 CHESTNUT STREET PHILADELPHIA, PA.

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HIGHER

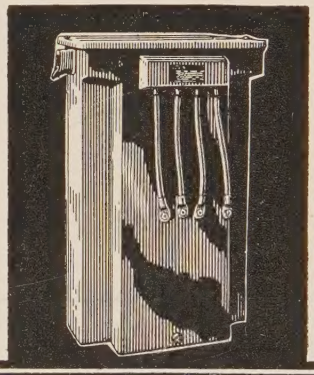


ONE reason why sports are generally regarded as valuable preparation for business is because they teach concentration upon a definite objective . . . in this case it is clearing the bar.

For almost four decades the Kuhlman organization has been "clearing the bar" by satisfying the transformer requirements of the utilities. Kuhlman frequently raises the bar . . . making improvements that add to the reputation of Kuhlman Transformers for long life and low losses. Consequently, Kuhlman Transformers are constantly achieving a higher place in the esteem of the light and power companies.

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TREATING the soil in order to obtain satisfactory ground resistance can be done most satisfactorily by this latest Murray development. After the rod has been installed merely pour the treating solution into the non-corrosive—long life copper tube.

It is no longer necessary to treat the ground external to the rod.

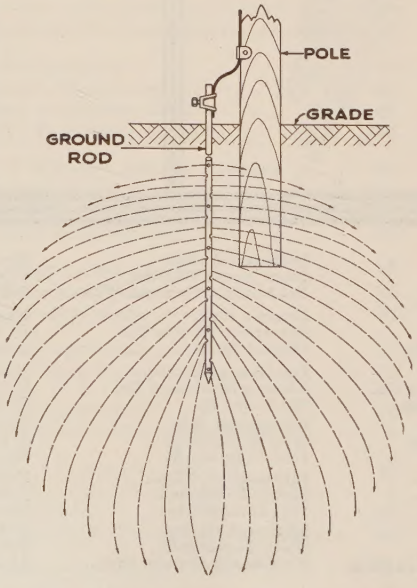


ELIMINATE guesswork—keep your grounds at the resistance best for your operating conditions.

In booklet we have compiled a quantity of interesting data.

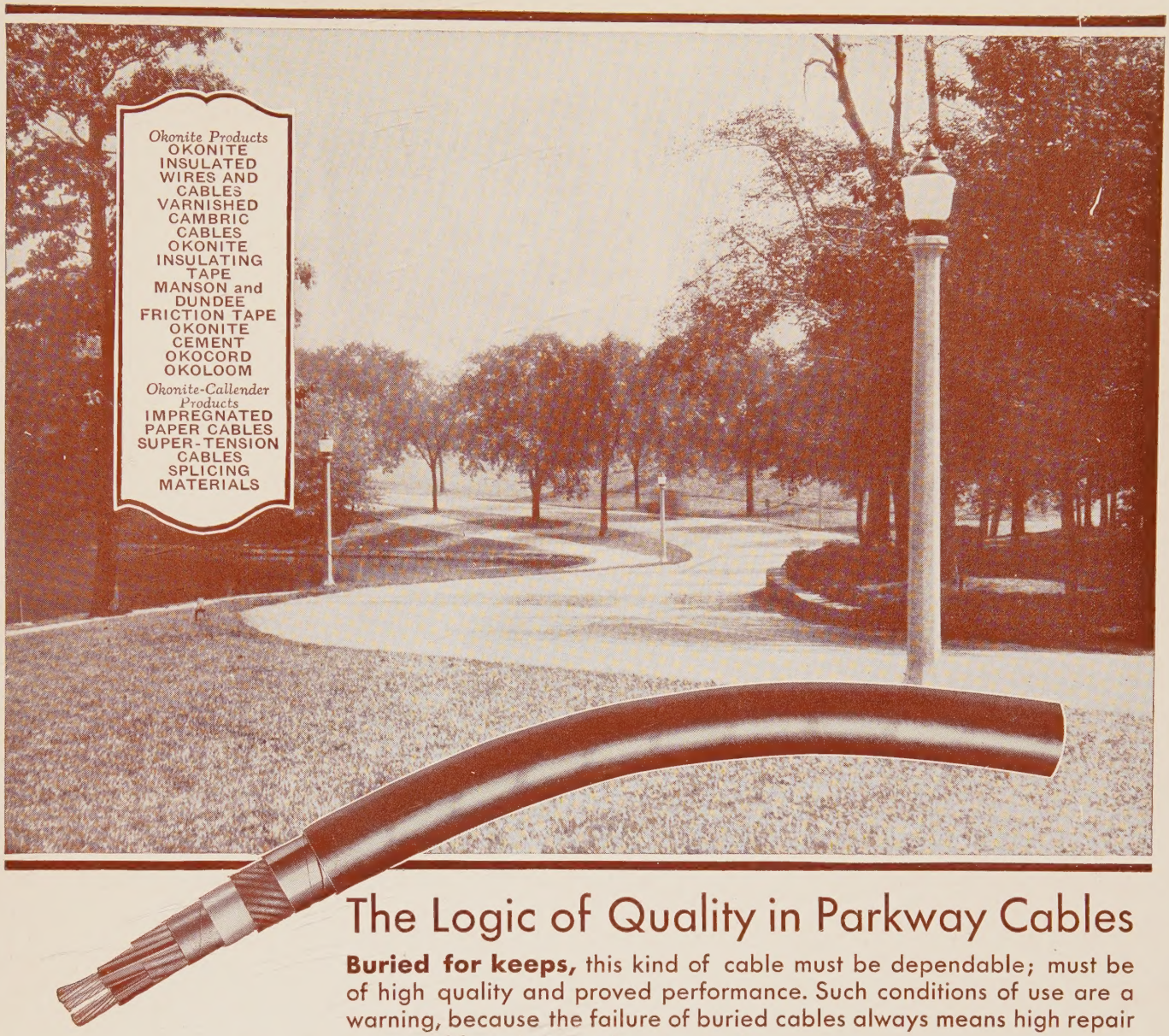
Murray Copper Tube Grounds are in wide use. Make a test installation,—that will convince you.

MURRAY
COPPER-TUBE
GROUND ROD



REGULATES
GROUND
RESISTANCE

METROPOLITAN DEVICE CORPORATION
1250 Atlantic Ave., Brooklyn, N. Y.



The Logic of Quality in Parkway Cables

Buried for keeps, this kind of cable must be dependable; must be of high quality and proved performance. Such conditions of use are a warning, because the failure of buried cables always means high repair costs and long interruptions to service.

The reliability of Okonite Parkway cables has been thoroughly tested by years and years of diversified use and they can be installed with the confidence that they will **perform for keeps.**

They will demonstrate the logic of quality in the same way that all Okonite products have demonstrated it for fifty years.

Okonite Parkway cables are made for all uses with either steel or non-metallic armoring.

Advice will gladly be furnished on any installation problems and our booklet "The Story of Parkway Cables" will be mailed upon request.

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Founded 1878

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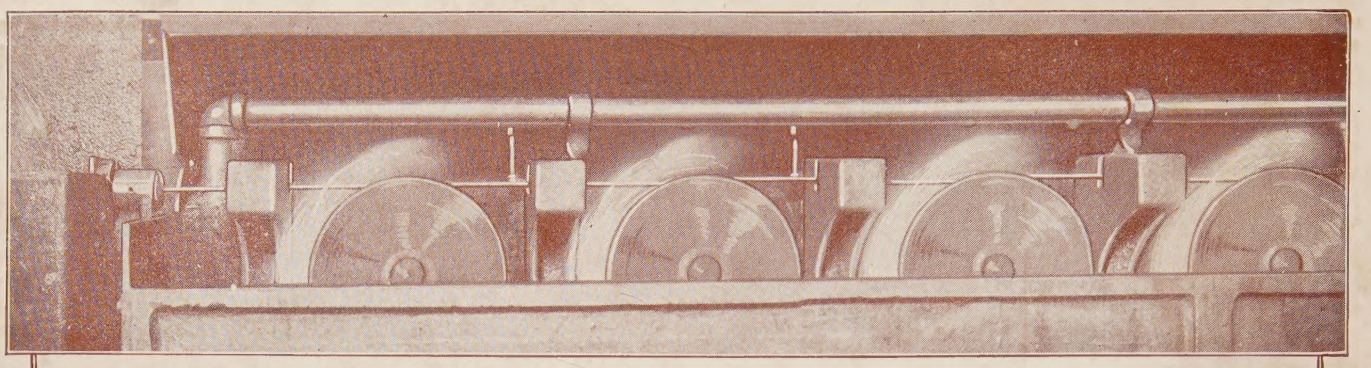
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From Copper Rod to Magnet Wire on Spools

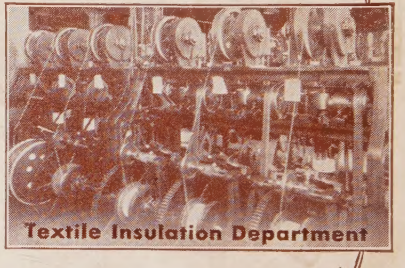
THE remarkable uniformity of Belden Magnet Wire, from spool to spool or from carload to carload, is universally recognized by large wire users.

In footage, the annual output of Belden Magnet Wire runs into billions of feet. Yet this tremendous output is maintained within such close tolerances, at each step, that every foot of finished wire is of accurate gauge, "dead soft," and perfectly insulated throughout the entire spool.

Such excellence is the result of long experience. Furthermore, every operation from wire drawing, annealing, enameling, insulating, spooling, to final inspection is done under one management. Such Belden facilities provide a source of supply which is dependable for quality and delivery.



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